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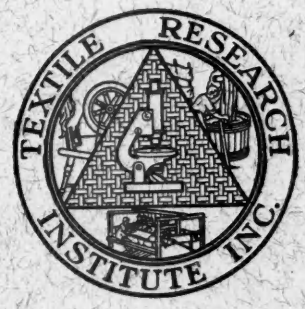

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TEXTILE RESEARCH JOURNAL

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Some Remarks About Resilience of Textile Materials*

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1. Resilience of Fabrics

Resilience is primarily a property of fabrics. Whether or not a given fabric exhibits it to an expected degree can, probably, be established with full certainty only by making a suit of this material and wearing it for a certain period. The extent to which the suit keeps its shape and drape, the absence of bulges at the knees and elbows, and the disappearance of wrinkles which are formed during daily use after hanging overnight will characterize the fabric as to the extent of its resilience.

However, textile experts are capable of predicting the practical resilience of a fabric with fair approximation on the basis of rapid, subjective tests. The most simple and widely used is the "clenched-fist" test. A piece of fabric (about 50–100 square inches) is placed in the hand and compressed in such a way that it forms an irregularly folded mass. After a period of a few seconds the fist is opened suddenly and the unfolding of the fabric is observed. The compression and relaxation are repeated several times with different force and at different rates. Judgment is then passed on the resilience of the material according to the following observations:

(*a*) How the fabric plies or folds under compression. In order to be resilient it must offer a certain moderate resistance to the closing of the fist. If it yields too easily, it may be classified as "limp" or "dead"; if it resists too much, it will appear to be "boardy," "stiff," or "harsh."

(*b*) How the fabric behaves upon sudden opening of the fist. A resilient material will spring back rapidly into a fairly open state, demonstrating a certain "springiness," "loftiness," or "liveliness." If it recovers too slowly, it will be characterized as "limp" or "slow."

(*c*) How the fabric appears, after repeated compression, when flattened out on a table. If a fabric is resilient, it will show only the presence of indistinct, shallow wrinkles, which will disappear completely in a few minutes. This last property is also referred to as "crushproofness."

It is evident that the clenched-fist test is highly subjective and empirical, but it is remarkable how closely its results match if a number of experienced textile technologists apply it to a number of fabrics. They will, very probably, all grade these fabrics in the same manner and all will be able to predict with reasonable accuracy the performance of the material in actual use.

Nevertheless, attempts have been made, and are still being made, to develop a more reliable and reproducible test on the basis of an apparatus which yields certain figures for the characterization of the fabric. Much valuable work has been done in this

* Material in this paper was presented to The Fiber Society, March, 1946, and the A. A. A. S. Gibson Island Conference, July, 1946.

field during the last few years [7, 10, 21], and under the leadership of Amick [2], Fox [5], Hamburger [6], Harris [8], Hindman and Krook,* Robinson [16], Schiefer [18, 19, 20], and Schwarz [5] very interesting results on the definition and numerical characterization of the resilience of fabrics have been obtained.

This progress in the reproducible characterization of this important fabric property raises the question: To what extent is the resilience of a given fabric caused by the fibers of which it consists, and to what extent does the individual structure of the fabric itself (knitted, woven, braided, etc.) contribute to its resilient behavior?

It is not the intention to attempt in this short article to answer this question in detail, but—even without doing so—it is fairly obvious that the type of knitting or weaving is of considerable importance for the resilience of a fabric. On the other hand, experience has shown that the character of the fibers from which the fabric is built is also of great influence on the resilience of the latter. Certain fibers, such as wool, Aralac, silk, and cellulose acetate rayon, are particularly well adapted for making resilient fabrics, whereas certain others, such as cotton, linen, viscose rayon, and nylon, cannot easily be woven into fabrics of pronounced resilience. This fact invites the consideration of the question: What properties must a fiber exhibit in order to permit the easy construction of a resilient fabric?

2. Resilience of Fibers

Attempts to answer the above question have led to the concept of the resilience of a fiber, although originally the term "resilience" was primarily and preponderantly applied to fabrics. In fact, it was found that the term "resilience" can be extended to fibers and it even seems that the empirical clenched-fist test affords a reasonably good means of obtaining a first rough estimate of the resilience of a fiber. It is carried out with a bunch or bowl of fibers instead of with a piece of fabric but aims at the same goal—namely, to find out how an irregular aggregate of loose fibers reacts to compression and subsequent rapid relaxation.

If a given fiber, such as wool, cotton, rayon, nylon, etc., is to be classified as resilient, such a bunch of irregular fibers should perform about as follows:

(1) It must offer a certain moderate resistance to compression. If this resistance is too little, the material is "limp"; if it is too much, the fiber is "harsh" or "stiff."

(2) It has to spring back vigorously and rapidly upon relaxation, even if it has been kept under compression for a considerable time. If the recovery is only a slow creep, the fiber will be classified as unresilient.

As in the case of fabrics, attempts are still being made to design instruments for a reproducible compression and relaxation of bunches of fibers, which will permit a numerical characterization of the behavior of various materials [5, 12, 17, 23]. It has also been attempted to correlate the composite quality of fiber resilience with simpler and more easily accessible properties, such as modulus of elasticity, creep, and work recovery [8, 13, 14]. All these attempts at quantitative measurement of fiber resilience together with the present broad knowledge of the qualitative aspects seem to indicate that the following factors are particularly important for the behavior of a fiber bunch upon compression.

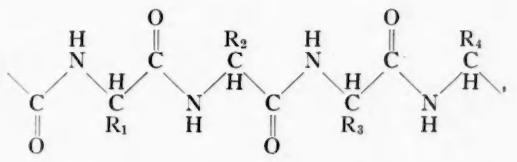
(*a*) *The Average Length and Diameter of the Fibers*

It is immediately evident that a certain minimum average length is necessary in order to make up an irregular fiber bunch which will not collapse upon compression. Fibers only a few millimeters long would be useless, even if each of them was highly resilient. A minimum length of 2 or 3 inches is probably necessary in order to obtain any compression resilience. Of great importance is the fiber diameter. The compression of the bunch leads, in general, to a bending of the individual fibers inside of the reversible limit and results in a storage of the compression energy in the bent filaments. The bending resistance of cylindrical rods is proportional to the fourth power of the radius, and coarse fibers will therefore offer more resistance to compression and exhibit more tendency to return in the straight state. A large diameter, however, conflicts with so many other properties of a fiber and of the resulting fabric, such as softness, hand, luster, etc., that the trend is to use finer and finer filaments. The problem is therefore to produce fibers of small diameter (two deniers and less) *and* high resilience.

* This paper, "Some Aspects of Compressional Resilience Defined," given at the same meeting of The Fiber Society, will be published in a later issue.

(*b*) *The Chemical Nature of the Material*

All present knowledge indicates that the chemical nature of the fiber is of preponderant importance for resilience. All protein fibers, natural and synthetic, exhibit high resilience. Leading among them are native keratin fibers—that is, all kinds of native wool, as well as spun proteins such as soya bean, zein, chicken-feather protein, and casein. The common structure of all these materials is that they consist of a very long and flexible backbone chain of the form



in which there is a frequent repetition of the carboxyl-amid group —CONH— in such a way that only one substituted methylene —CHR— separates two —CONH— groups. The methylene groups of the chain carry various (up to 20) substituents, R_1, R_2, R_3, etc., which in turn contain groups of various chemical nature and polarity (OH, NH_2, COOH, SO_3H, NH, S—S, etc.). One may, therefore, consider a keratin chain to be a very complex copolymer consisting of a large number of different monomers, but there seems to be a high degree of regularity in the arrangement of these monomers along the length of the chain. This long-range regularity distinguishes native proteins from the synthetic copolymers of the vinyl and butadiene type, in which the sequence of the various monomers appears to be a matter of statistics [1, 4, 22] rather than of a well-defined, long-range pattern. The variety and the regular arrangements of the substituents along the chains provide for a considerable degree of interaction between them, ranging from weak van der Waals attraction to such strong bonds as hydrogen bridges, ionic forces, and even covalent cross links [8]. There exist other fibers with —CONH— groups in the backbone chain—namely, native silk and nylon. Neither of them possesses the many different substituents of keratin and, although they both exceed keratin fibers considerably in strength, they do not exhibit the high resilience of keratin fibers. A group of other materials which permits the production of fibers which can be comparatively easily worked into resilient fabrics seems to be the various copolymers of vinyl chloride with other vinyl derivatives (vinyons). These copolymers also possess a backbone chain of considerable internal flexibility and, in this respect, are not too dissimilar to protein chains. Their substituents, however, such as Cl, acetate, OH, or various acetals, are very different in chemical nature from the substituents which are distributed along a protein chain. Nevertheless, they apparently provide for a certain degree of mutual attraction, which is due partly to comparatively weak polar bonds, partly to stronger ones, and partly to hydrogen bridges. The statistical distribution of the substituents prevents crystallization and provides for the rubbery nature of these materials. All these factors together seem to establish relatively favorable conditions for a resilient behavior of fibers made out of vinyl copolymers.

Cellulose, on the other hand, is a material which does not easily give resilient fibers. This may be due to the comparative stiffness of the chains, which is probably accentuated by the presence of a large number of strongly interacting hydroxyl groups. Their importance is emphasized by the fact that fibers made from cellulose triacetate and from technical cellulose acetate having 5 hydroxyl groups out of 6 acetylated lend themselves fairly easily to being woven or knit into resilient fabrics. The interaction between the chains is here smaller than in the case of cellulose, and moisture does not plasticize the acetylated cellulose as much as it does the unacetylated material.

Cellulose acetate is therefore intermediate between proteins and cellulose; it possesses two types of groups, which provide for the interaction between adjacent chains: the hydroxyl groups, which are capable of establishing strong hydrogen bonds, and the acetate groups, which can contribute only comparatively weak polar attraction. This dual interaction is favorable for resilience. On the other hand, the relative stiffness of the backbone chains does not permit cellulose acetate fibers to be very highly resilient.

(*c*) *The Degree of Order in the Texture of the Fibers*

The third factor which is of importance for the mechanical behavior of a fiber is its texture. All our present experience indicates that high polymer materials, such as fibers, films, injection- or compression-molded test pieces, extruded samples, etc., can consist of arrays with different degrees of order.

One extreme case is the disordered (amorphous, glassy, or liquid-like) state in which the segments of the polymer chains are arranged completely at random and comply only with the conditions of dense packing. This is the case in unstretched native rubber, in most synthetic elastomers, in many vinyl polymers and copolymers such as vinylites, vinyon, polystyrene, etc., and in commercial cellulose acetate. High polymers which are completely or preponderantly in this state are either rubbery solids or very viscous liquids (glasses). The other extreme is the crystallized (highly ordered) state, representative of which are filaments of highly oriented cellulose (Fiber G, Fortesan), nylon, Saran, polyethylene, silk, etc. However, all these samples still contain a certain (sometimes small) amount of material in the disordered state. In general, one has, therefore, to expect that a given fiber, film, or test piece will be represented by a certain mixture of ordered and disordered domains (crystallized and amorphous areas), the relative proportion of which is important for the technical properties and particularly for the resilience of the material.

It seems, therefore, that not only the chemical structure of the individual chain molecule, but also the physical texture of the arrangement of these molecules in the sample, determines its mechanical properties. If one wants a very stiff and strong fiber, it will be necessary to convert as much of the material as possible into the crystalline state and to orient all crystals parallel to the fiber axis. If, on the other hand, an extensible and soft fiber or film is required, one will keep a large proportion of the material in the disordered state. This importance of the order-disorder proportion (texture) in a high polymer material leads to the question whether one can make any statement regarding the relationship of the texture of a fiber to its resilience. This question is discussed below.

3. Arrangement of the Chain-Molecules and Mechanical Properties of Polymers

It may be worth while to consider very briefly the behavior of an ordinary organic substance.

At the freezing temperature of a liquid of small molecular weight, such as benzene, toluene, isoprene, etc., a very distinct change in the mechanical properties of the material takes place within a narrow temperature range. Below the freezing temperature ordinary substances are crystalline solids; they respond to shearing stresses by undergoing small (1 percent or less), predominantly reversible deformations and exhibit the long-range order (100 Å. or more) of a three-dimensional crystal lattice. Each molecule is held by attractive and repulsive forces of all surrounding particles in a relatively well-defined equilibrium position, about which it carries out rapid, quasi-harmonic vibrations. Transition of an individual molecule from one equilibrium position to another (self-diffusion) is extremely infrequent; the average amplitude of the vibrations amounting to only about 5 percent of the distance between adjacent equilibrium positions. Such systems appear to us as rigid, hard substances, having a definite shape and all the other characteristics of a solid body.

As the temperature is increased, the vibrations of the individual particles become more and more vigorous, and—at the melting temperature—the forces between the constituents of the lattice can no longer maintain the long-range order of the crystal, and the whole structure breaks down. The result is a liquid, characterized by the absence of any far-reaching geometric order. The nearest neighbors of any individual molecule, however, are arranged about the latter in much the same manner as in the crystalline state, but molecules a few angstroms farther away are distributed practically at random. Each single particle, again, carries out rapid quasi-elastic vibrations about an equilibrium position; but this equilibrium position itself (being a position of minimum potential energy) is not fixed in its location and the molecule undergoes, in addition to vibrations, an irregular translational Brownian movement [15], which makes it change its place rather frequently; self-diffusion is rapid. The lack of long-range order prevents a liquid from sustaining shear or stress and from assuming a definite shape: it flows. Eyring [3], Lennard-Jones [10], and their coworkers have succeeded in giving a very satisfactory explanation of many important properties of liquids on the basis of this picture.

A liquid can be supercooled below its equilibrium melting temperature, thus retaining the characteristics of its disordered (amorphous) geometrical structure. The coefficient of viscosity η increases with decreasing temperature, T, roughly following an exponential relationship

$$\eta = A \exp (B/T),$$

where A and B are constants, and at a sufficiently low temperature the material becomes hard and

TABLE I. A COMPARISON BETWEEN LOW AND HIGH MOLECULAR-WEIGHT SUBSTANCES

Behavior of ordinary substances:

Crystalline solid state		Liquid state
Long-range molecular order	*Melting point*	Short-range molecular order
No Brownian motion		Rapid Brownian motion
Sustains external forces; shows low-range, high-modulus elasticity		Does not sustain external forces; flows and has low viscosity

Behavior of polymers:

Crystalline solid state		Rubbery state		Liquid (molten) state
Long-range molecular order	*Brittle point (range)*	Short-range molecular order, but long-range entanglement	*Softening point (range)*	Short-range molecular order
Both Brownian movements are frozen in		Internal Brownian motion is rapid, but external Brownian motion is still frozen in		Both Brownian motions are activated
Sustains external forces; shows low-range, high-modulus elasticity		Sustains external forces; shows long-range, low-modulus elasticity		Does not sustain external forces; flows and has high viscosity

brittle; it is then called a glass. The transition from rigid glass to viscous liquid occurs frequently in a relatively narrow temperature range (the softening point) with no sudden change in structure and with no discontinuity in the primary thermodynamic variables, such as heat content, free energy, and specific volume. Thus in the case of ordinary (low molecular-weight) organic substances the relationship between the crystalline, glassy, and liquid states can be represented by the scheme of Table I.

High polymers consisting of long chain-molecules exhibit a more complicated behavior. The strong chemical bonds inside the individual chains are not (or only very infrequently) severed during the normal mechanical deformation of the polymer, such as stretching of rubber or spinning of nylon, or during the various thermal treatments, such as annealing or molding. The changes in shape which take place during these processes occur at the expense of opened (and reclosed) bonds between the individual chains, which are not due to chemical forces but to the various types of intermolecular interaction, such as hydrogen bridges and van der Waals forces.

Let us, from this point of view, compare the crystal lattice of isoprene with that of stretched (or frozen) rubber and consider what happens if one increases the temperature of both systems.

In frozen isoprene, each individual molecule (C_5H_{10}) is located in a definite equilibrium position, about which it undergoes irregular, quasi-harmonic vibrations. The distance between any one molecule and its next neighbor is about 4 to 5 Å., while the interatomic distances within the molecule are only 1.0 to 1.5 Å. This elucidates the fact that the C_5H_{10}-molecule is held together by strong chemical bonds, having dissociation energies of 70 k. cal./mol. or more, forming a well-defined unit in the lattice, while the forces between the molecules are of the much weaker, van der Waals type (about 5–8 k. cal./mol.). Nevertheless, below the melting temperature, the bonds between molecules suffice to maintain the long-range order of a crystal lattice, and frozen isoprene is a hard, rigid substance. Above the melting temperature, however, all long-range connections between the molecules disappear and the result is a liquid with rapid self-diffusion of the individual molecule and small coefficient of viscosity (about 10^{-2} poise).

In frozen rubber, each individual isoprene residue (C_5H_8) and each single C and H atom within it also vibrate about a definite equilibrium position, but a thorough investigation of the lattice shows that each isoprene residue is particularly close to two other residues, indicating that long linear chains of residues exist, within which *all* next-neighbor distances correspond to strong chemical bonds. The main valence chains of isoprene extend parallel to the direction of the stress, have a length of several thousand monomers, and represent the backbone of the whole structure. In all directions perpendicular to the axes of the chains the distances between adjacent molecules are determined by normal van der Waals forces.

This lattice, therefore, is highly anisotropic: strong forces along the parallelized chains, weak forces perpendicular to them. As one increases the temperature, the weak intermolecular bonds gradually are severed and thus the lateral arrangement of the chains is disturbed and eventually destroyed. They start rotating about their axes, changing their mutual distances and eventually curling and coiling up in an irregular way. However, while the weak bonds between the individual chain molecules are opened, the strong (chemical) linkages within them remain unaffected. The molecules are not degraded at temperatures at which the lattice structure already breaks down. This has the important consequence that although the long-range geometrical order of the lattice disappears when the temperature is raised to the softening point, a long-range entanglement due to the unaltered existence of the long-chain molecules is maintained. This long-range entanglement is responsible for the fact that, at the softening point of a polymer, we get not a fluid liquid but a rubbery solid.

An individual isoprene residue in (amorphous) unstretched rubber vibrates with about the same intensity as does an isoprene molecule at the same temperature in liquid isoprene, and it will also carry out about the same short-range Brownian movement; but owing to its position in the chain-molecule it will not be able to diffuse farther away from its original positions without affecting other parts of the chain to which it belongs. This geometric restriction of the various segments of the flexible linear macromolecules due to the strong bonds between them produces a long-range entanglement, which enables the material to sustain moderate stresses or shears, and hence to maintain a certain definite volume and shape and to resist elastically any attempt at deformation. In this sense rubbers have a state between the solid and the liquid, just as glasses do, and one can briefly make the following distinction:

Glasses are liquids with high viscosity; rubbers are liquids with long-range entanglement (Table I). The self-diffusion of chain-segments is not essentially affected by the long-range entanglement, and, therefore, it is rapid, whereas any displacement of the large linear molecules as a whole is impeded by their mutual interaction over long ranges and therefore is very slow. The irregular motion of portions of the chains under the influence of the temperature has been termed by W. Kuhn [9] "internal" or "micro" Brownian movement; the displacement of the macromolecules as a whole is referred to as "external" or "macro" Brownian movement.

Using these terms, we can briefly say (and with a certain degree of oversimplification): rubbers are materials having rapid internal but slow external Brownian movement. It is this combination that characterizes the rubbery state.

4. Significance of the Two Different Brownian Movements

Let us first consider for which essential feature of rubberiness the two types of Brownian or molecular motion are responsible.

If we start stretching a rubber, we expect it to begin deforming at comparatively low stresses; it is supposed to be a soft, extensible material, having a small initial Young's modulus. For typical elastics (soft rubbers or gum stocks), Young's modulus is between 10^6 and 10^7 dyne/cm.^{2} (15 to 150 lb./in.^{2}). If a material is to extend appreciably under the influence of such small stresses, it needs a considerable degree of internal mobility, much like that of a normal liquid. In fact, rubbers have many properties in common with ordinary liquids; they possess a compressibility very similar to that of liquids. Poisson's ratio for all "soft" elastics is in the neighborhood of 0.50; the thermal expansivity of rubber is of the same order of magnitude as that of ordinary liquids, and (perhaps most surprising) the solubility of gases (hydrogen, oxygen, etc.) and solids (sulfur, selenium, etc.) in rubbers resembles rather closely the solubility of the same materials in ordinary liquids. The "local" fluidity of elastics produced by the fast internal Brownian motion is also responsible for this rapid contraction. In a stretched rubber certain segments of the individual chains assume configurations whose free energy is larger than that of those in unstretched rubber. Therefore, as soon as the external force ceases to act, these portions will start to diffuse back into their unstrained (equilibrium) positions, which correspond to a minimum free energy and represent the relaxed state of the sample. How quickly this contraction takes place depends upon the rate of segment diffusion, which determines the "local" fluidity of the material.

Certain materials "snap" back into their original shape, because segment motion is fast; others "creep" back, because the local mutual interaction of the chain segments is strong and prevents them from assuming

their unstrained positions within a short time. Natural rubber, neoprene, butyl-rubber, or the Buna types are examples of the first case; polystyrene above 80°C, vinylites, or moist polyvinyl alcohol are examples of the other. In order to get a good, snappy elastic, one has to keep the internal Brownian motion as rapid as possible, which means one has to accentuate the local liquid character of the system.

On the other hand, if we provide in an elastomer for nothing but this high local fluidity and keep a macroscopic sample of it under stress for a certain length of time, the material will flow. It will not sustain the imposed stress or shear, but, with the very aid of the rapid internal Brownian motion, will relax into the extended state instead of into the contracted. Hence it will behave like a viscous liquid or plastic rather than like a rubber. To prevent this permanent loss of shape, one has to provide for strong long-range entanglement, which makes the external Brownian movement (slipping of whole chains along each other) so slow that it cannot produce any appreciable permanent set within the time the sample is in its extended state. In general, the mutual attraction of the chain by van der Waals forces alone does not provide for a sufficiently stable long-range entanglement to conform with practical requirements. Therefore, one usually produces a system of irregularly distributed, widely spaced fix points. They provide a stable but highly deformable network throughout the sample, which can be stretched several hundred percent and then return to its original shape, because its individual knots are connected with one another by flexible chain-molecules. Such fix points can be made in different ways. One way is to produce strictly localized, strong chemical bonds between the individual chains, such as sulfur, oxygen, or methylene bridges, as is presumably done during the various processes of curing and vulcanizing. Another way is to have groups of particularly strong molecular interaction (hydrogen bonds, strong dipoles, highly polarizable groups) or of great bulkiness (phenyl, benzyl, naphthyl groups) randomly distributed along the chains, thus producing an irregular network of areas with high molecular adhesion. Still another method is to distribute very small particles with high adsorption power (active fillers) in the polymer, which provide for fix points by adsorbing parts of the mobile chains irreversibly on their active surfaces.

In all these cases, the localized and infrequent strong links between the individual flexible chains suppress the macro-Brownian movement sufficiently to avoid permanent flow of the sample as a whole, while they leave the micro-Brownian movement sufficiently unaffected to make possible rapid extension and contraction.

This discussion shows that a polymer exists not in two but in three condensed states: the solid, the rubbery, and the liquid. In the solid state (crystal or glass) both Brownian movements are frozen in; in the rubbery state the "micro" Brownian motion is activated, while the "macro" Brownian movement is still frozen in; and, finally, in the liquid state of a polymer (in the melt or in a highly swollen sample) both Brownian movements are activated. Under the influence of an external force the solid state allows only short-range, high-modulus elasticity, the rubbery state permits long-range, low-modulus elasticity, and the liquid state provides for flow. An ordinary organic substance has only two condensed states, the solid and the liquid; there exists only one type of Brownian motion which is activated in the latter and frozen in the former state. These two phases, solid and liquid, are in equilibrium with each other at the freezing (or melting) temperature. In the case of polymers there are two characteristic temperatures (or temperature ranges): the brittle temperature, which separates the solid from the rubbery state, and the softening temperature, which separates the rubbery from the liquid state. Table I attempts to give a schematic picture of this situation.

5. Significance for the Resilience of Polymers

Considering the facts as discussed in the preceding paragraph, it becomes clear that if one wants to produce a polymer for the production of a resilient fiber one has to synthesize chain-molecules with a DP around or above 1,000 which have a certain degree of internal flexibility. This material has then to be brought into the proper physical state or into the proper mixture of states. And here we realize that we have at our disposal three different phases: the solid, the rubbery, and the liquid. The task of bringing the polymer into the best physical state is similar to that of a metallurgist who attempts to find the best properties of his alloy in the phase diagram of his system, with the difference that this organic chemical metallurgy has one more state at its disposal—namely, the rubbery. This is due to the presence of the long chain-molecules and is of great importance for the imparting of resilience.

It is now obvious that, if one wants to produce a resilient fiber which at the same time has a high tensile strength, one will have to accentuate the solid state in order to get the required tenacity, but one also has to provide for enough rubberiness to obtain sufficient resilience. Any liquid (glassy) constituent in such a fiber would be unwelcome because of the permanent set to which it leads under prolonged external stress. If one aims at the production of a typical soft rubber, it is necessary to have the bulk of the material in the rubbery state, with perhaps some crystalline domains in order to provide for a sufficiently strong fix-point system. Finally, in producing a plastic, one would have to provide for an appropriate mixture of solid and liquid material with as little rubberiness as possible in order to guarantee smooth extruding, casting, or molding without recovery after the desired shape has been obtained.

In this sense it can be said that fibers, plastics, and rubbers are not intrinsically different materials; they are only different combinations of the three fundamental states in which organic high polymers can appear; and there exists, obviously, a continuous multitude of systems, starting with extreme fiber properties and ending with extreme rubber qualities, depending essentially upon the degree to which the crystalline, rubbery, and glassy states are represented in the sample. It is this balance which has to be set up in the proper way if one wants to combine strength with resilience. From the practical point of view there will always be a compromise between the possibility of having a stronger fiber which is more difficult to convert into a resilient fabric, and a weaker one which can be woven or knitted into a resilient system much more easily. In arriving at the proper compromise it is also important to locate the various constituents (crystalline and rubbery) in the most advantageous areas of the fiber. A filament having a crystalline skin and a rubbery core will be less desirable than one having a highly crystalline and oriented core and a rubbery (amorphous) skin. It is here that minute changes in the spinning, stretching, relaxing, washing, and drying of the filaments effect rather noticeable changes in the ultimate combination of strength and resilience.

It appears, therefore, that the production of a strong fiber which lends itself easily to be converted into a resilient fabric cannot be achieved by emphasizing one principle, but only by a very careful and well considered combination of the essential factors. One has to start with a polymer of high DP which has flexible backbone chains and a supply of substituents of various chemical nature. These chains must then be brought partly into a highly ordered state, partly into a rubbery state, and this phase must be properly distributed across the cross section of the filament. It is easy to see that such a delicate balance can be set up only by a thorough empirical procedure, but it may be that a few guiding principles as they have been tentatively offered in this article are sometimes of a certain value as working hypotheses.

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Fiber from Peanut Protein

I. The Production and Properties of Sarelon

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Research at the Southern Regional Research Laboratory has resulted in the development of a fiber produced from peanut protein which has been named Sarelon. This fiber is light-cream-colored in its natural state and possesses a soft hand and a warmth similar to that of wool. It possesses an affinity for dyes normally used on protein fibers and may be dyed with vat and direct cotton dyes. Its major weakness, like that of all synthetic protein fibers, is its low strength.

Introduction

The concept of the artificial production of a fiber having properties similar to those of silk was first set forth by Robert Hooke in 1664 [1]. It was, however, not until the end of the nineteenth century that systematic research was begun on an inexpensive, artificial substitute for silk. Oddly enough, this work culminated in the production of rayon—a cellulose fiber produced from cotton linters, wood pulp, or other cellulosic plant materials. In order to produce a fiber having chemical and physical characteristics similar to those of natural protein fibers, such as silk or wool, it would appear logical that a plant or animal protein should be employed as the raw material for the process.

In 1898 Millar [2] obtained a patent covering the spinning of casein dissolved in acetic acid and in 1904 Todtenhaupt [3] patented a process for spinning an alkaline solution of this protein into an acid coagulating bath. Commercial success on a limited scale was realized by Ferretti [4] with the production of Lanital, an artificial fiber made from casein, by Snia Viscosa in Italy. Patents on the production of casein fibers were also obtained by Whittier and Gould [5].

With the advent of Lanital, a new stimulus was given to the development of artificial fibers from proteins. Although the major technical and commercial success has been achieved in the utilization of casein for fibers, such as Lanital and Aralac, vegetable proteins—notably those from soybeans and peanuts—have also been used for the production of similar types of fibers. The production of a fiber from soybeans has been described by Boyer [6] and one from peanuts—namely, Ardil—has been described by Traill [7]. These fibers are as yet not available commercially, but are being produced on a pilot-plant scale.

Proteins as they occur in natural nonfibrous materials have generally a globular, coiled structure which they retain even after extraction and purification. On the other hand, the natural protein fibers, such as silk and wool, exhibit a linear orientation of the molecules which indicates that the protein chains are uncoiled and that greater opportunity is given for interaction between the active groups in the adjacent chains. Such interaction is necessary in order to attain the desired mechanical strength in the fiber. In order to convert natural globular proteins into filaments having strengths approximating those of the natural protein fibers it is necessary to orient the proteins in the filament and stabilize this orientation by interaction between adjacent groups in the parallel-oriented chains.

The present article describes some of the more recent efforts to produce such a fiber from peanut protein, which has been named Sarelon. Sarelon is a light-cream-colored fiber with a soft, pleasant hand intermediate between that of silk and of wool. Upon contact with the skin it has a warm feel and it absorbs moisture in a manner similar to wool. Since the yarn is relaxed when removed from the spin-bobbin, it has a high degree of dimensional stability

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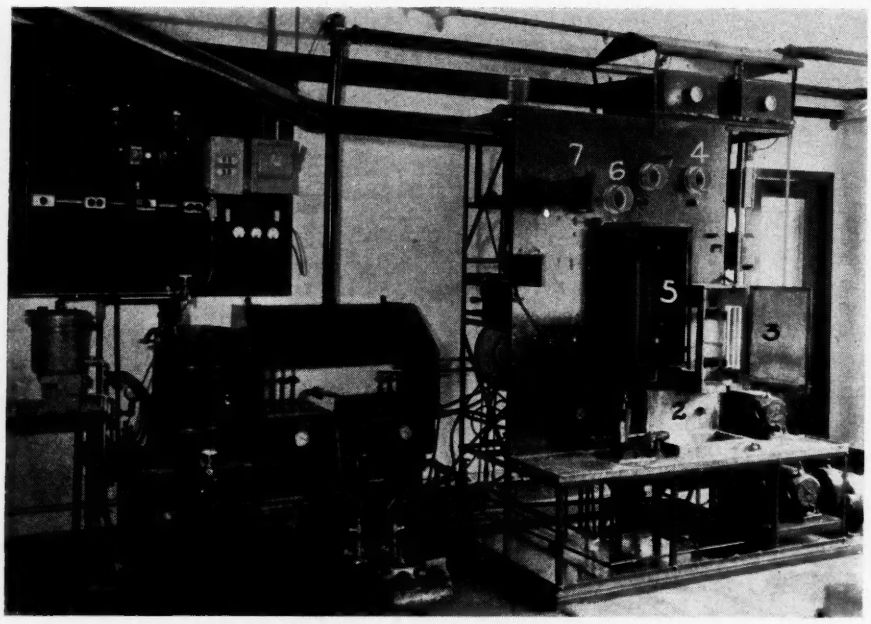

FIG. 1. *Spinning machine used in the production of Sarelon. 1—Protein solution; 2—fiber-coagulation bath; 3—first hardening treatment; 4—godet-stretching; 5—second hardening treatment; 6—godet-stretching; 7—take-up bobbin.*

and does not shrink appreciably in hot water. Sarelon has an affinity for dyes normally used on natural protein fibers. The rate of dye adsorption on Sarelon is greater than on wool. It also has a reduced wet-fastness for acid dyes. Solid shades may be obtained by dyeing wool and Sarelon unions with a level-dyeing acid dye from a boiling dye bath containing Glauber's salt and acid. Sarelon may be successfully dyed with vat and direct cotton dyes; this characteristic makes possible, by the selection of suitable dyes, the production of a cellulose and peanut-protein-fiber union having solid shades.

The major weakness of Sarelon, like that of other synthetic protein fibers, is its low wet strength. Generally, neither the treatments to produce boil-resistance nor treatment with aluminum salts in the presence of formaldehyde at temperatures up to and above 80°C, as employed in the production of casein fiber, increases its wet strength.

Apparatus and General Methods

Spinning Machine

In present industrial practice, protein fibers are made by the staple process, in which the yarn is cut to the desired length for blending with other fibers. However, cutting the yarn into staple lengths and blending conceal many of the fiber's properties; therefore the continuous system for low-denier yarns was considered more suitable for the experimental purposes of this investigation. The protein fiber was made by the "wet" process in a manner similar to that employed for viscose rayon production [8]. The actual spinning operation used for peanut-protein fiber production was more complicated than that required for viscose-rayon production of normal-strength yarns.

Freshly coagulated protein fiber is very weak and cannot immediately be stretched the desired amount to decrease its size and increase its strength; therefore, it is essential that the fiber be further treated with curing solutions. For this purpose a multiple-bath spinning machine with individually controlled variable components was designed.

The spinning machine shown in Figure 1 consists of a steel frame approximately $7 \times 7 \times 2$ feet to which are attached the several variable-speed drives necessary to produce differences in surface speeds during the travel of the yarn. A 1-h.p., 1,725 r.p.m., constant-speed motor reduced to 690 r.p.m. is connected to two variable-ratio (nonslip) chain drives placed one above the other and connected by a chain. The lower variable-ratio chain drive, through chain, sprockets, and gears, controls the metering gear-pump assembly located in the center of the table top. The upper variable-ratio chain drive, connected to a horizontal shaft, controls the over-all speed range of the various sets of delay rolls and godets (glass wheels) for directing and stretching the yarn. Each set of delay rolls or godets is individually controlled through a V-belt variable-speed pulley. The take-up

bobbin is driven by a ¼-h.p., 1,725 r.p.m., constant-speed motor which is reduced to 200 r.p.m. and connected to a variable-speed pulley for driving the bobbin shaft and traversing mechanism.

The delay rolls for treating and storing the yarn (*3* and *5*, on Figure 1) are supplied with aqueous salt solutions from constant-level tanks located on top of the spinning machine over each set of delay rolls. The salt solutions flow by gravity to the delay rolls and then are collected in the heating tanks located on the left of the machine. In the heating tanks the temperature of the cooled solution is again raised to the desired value, and the solution is then pumped back to the constant-level tanks.

The spinning solution is contained in a 500-milliliter, closed, hard-rubber tank to which air pressure is applied to assure a positive feed of protein solution to the metering pump. This pump forces the spinning solution at a constant rate through a viscose-rayon candle filter and thence through a glass goose-neck to the spinneret. A standard, platinum-gold viscose-rayon spinneret with a 0.5-inch-diameter face containing forty 0.1-millimeter holes arranged in concentric circles is employed.

Upon removal from the spinning machine, the yarn is after-treated in a curing solution, washed free of excess salts and formaldehyde, finished (if desired), and then dried.

Preparation of the Protein

Peanut kernels are enveloped by thin skins usually of a reddish-brown color. These skins, if left on the seeds and not pretreated before the protein is extracted, cause the protein to be very dark in color and unsuitable for utilization in fiber production. Removal of the skins by the blanching process generally employed by the food industries is costly and ordinarily subjects the kernels to a high temperature. Moreover, since the application of temperatures higher than 50°C at any stage during preparation of the meal or protein appears to be detrimental to the properties of the fibers, such a method is unfeasible for removing the color.

Several years ago a number of white-skinned varieties of peanuts were developed and grown on a limited scale in this country [9, 10]. One of these varieties was used in the early work on the development of Sarelon. Subsequently a simple and inexpensive method was developed and described by Burnett [11] which does not require the use of a high temperature for the removal of the alkali-soluble color from the skins. This is accomplished by dipping the peanut kernels in dilute lye solution at room temperature, rinsing the kernels to remove excess alkali, and drying. Although the protein used in the experiments to be described was obtained from white-skinned peanuts, subsequent experiments have demonstrated that protein prepared from red-skinned peanuts from which the color has been removed by dilute sodium hydroxide yields fibers equally as good as those obtained from the white-skinned variety.

To avoid excessive heating of the peanuts, removal of the oil from the seeds was accomplished by solvent extraction. The residual meal remaining after removal of the oil was treated in the ratio of one part of meal to ten parts of a dilute-sodium-hydroxide solution of such concentration that the pH value of the mixture was in the range of 7.5 to 8.0. This mixture which contains the dilute alkali-soluble protein in solution was kept at 25°C for ¾ hour, and then separated into soluble and insoluble fractions by a vibrating screen. The protein solution was clarified by either filtration or centrifugation. Precipitation of the protein from the clarified filtrate was carried out at 25°C by bubbling sulfur dioxide into the solution until the isoelectric range (pH 4.5–5.0) of the peanut-protein mixture was reached. The resultant protein curd was allowed to settle overnight and was then separated from the supernatant liquors by decantation and dried at 50°C. Because of the method of preparation, the curd was contaminated with sulfites which were removed along with soluble nonprotein materials either by washing the curd before it was dried or by leaching the protein after drying [12].

Preparation of Spinning Solutions

The solutions generally used in these experiments contained 18–24 percent protein. They were made from a single lot of leached peanut protein by mixing 135 grams of the protein with water and then adding an amount of 2.4*N* sodium hydroxide sufficient to obtain the desired pH. Stirring was continued until the protein was completely dissolved. Then, as desired, such chemicals as oils, emulsifiers, or plasticizers were added. Before spinning, the solutions were aged for 2 hours and any entrapped air or other gas was removed by centrifugation.

TABLE I. EFFECT OF ADDITION OF CHEMICALS TO PROTEIN SOLUTION BEFORE SPINNING (135 GRAMS OF PROTEIN USED IN ALL PROTEIN SOLUTIONS)*

Experiment No.	Protein solution: Materials added other than NaOH and H_2O	Protein solution: NaOH 2.4N (ml.)	Protein solution: H_2O (ml.)	pH	Viscosity†	After-treated in NaAc buffer-CH_2O solution: Strength (g./den.) Dry	Strength Wet	% Elongation Dry	% Elongation Wet	After-treated in NaAc buffer-CH_2O solution and oiled: Strength (g./den.) Dry	Strength Wet	% Elongation Dry	% Elongation Wet	After-treated in NaCl, HCl, and CH_2O solution: Strength (g./den.) Dry	Strength Wet	% Elongation Dry	% Elongation Wet	After-treated in NaCl, HCl, and CH_2O solution and oiled: Strength (g./den.) Dry	Strength Wet	% Elongation Dry	% Elongation Wet	Openness
226	None	66	325	11.5	34°	0.28	0.10	2.5	38.0	0.36	0.10	3.0	46.0	0.60	0.13	6.0	39.0	0.52	0.11	5.0	35.0	poor
227	None	73	350	12.0	30°	0.56	0.15	4.0	36.0	0.56	0.13	5.0	33.0	0.58	0.13	7.2	27.0	0.59	0.11	8.8	23.0	poor
228	None	79	325	12.5	29°	0.59	0.13	14.2	21.0	0.45	0.12	4.5	37.0	0.61	0.13	25.0	22.0	0.45	0.12	7.0	28.0	poor
230	5 ml. dibutyl tartrate	95	350	12.3	10°	0.56	0.13	5.0	36.0	0.49	0.14	4.0	39.0	0.59	0.13	6.0	21.0	0.59	0.11	9.0	22.0	poor
231	5 ml. dibutyl phthalate	74	350	12.2	29°	0.57	0.12	7.0	33.0	0.55	0.11	5.0	36.0	0.56	0.13	9.0	23.0	0.55	0.11	7.0	23.0	poor
232	5 ml. tritertiary amyl aconitate	74	475	11.5	28°	0.57	0.16	7.0	30.0	0.57	0.14	4.0	40.0	0.61	0.14	6.0	28.0	0.59	0.14	7.6	25.0	poor
233	5 ml. tributyl aconitate	74	350	11.8	32°	0.55	0.13	7.0	32.0	0.49	0.12	4.2	38.0	0.56	0.12	14.0	22.0	0.51	0.12	6.0	26.0	poor
237	1 ml. diglycol laurate	74	350	12.2	18°	0.59	0.16	9.4	26.0	0.54	0.13	4.8	33.0	0.60	0.13	8.0	20.0	0.50	0.13	7.5	22.0	good
240	1 ml. diglycol laurate and 2 ml. peanut oil‡	74	350	11.9	28°	0.59	0.17	11.8	28.0	0.48	0.12	8.0	36.0	0.59	0.15	10.5	21.5	0.51	0.13	10.0	25.0	very good
246	5 ml. dibutyl tartrate, 1 ml. diglycol laurate, 2 ml. peanut oil‡	95	425	12.0	5°	0.69	0.24	5.1	41.2	0.56	0.17	5.1	44.4	0.67	0.18	11.8	25.5	0.62	0.15	9.7	22.0	very good

* Samples conditioned at 70°F and 65 percent relative humidity for 24 hours. Tested on an IP-2 Scott tester with a 250-gram carriage, 10-inch sample employed. Results are average of 10 tests.

† MacMichael degrees, wire No. 26.

‡ A refined, deodorized, and winterized peanut oil employed.

Extrusion and Treatment on Spinning Machine

The coagulating bath (*2*, on Figure 1), which was held at 25°C, contained by weight 5 percent sulfuric acid, 20 percent sodium sulfate, and 15 percent dextrose. The fiber emerging from the coagulating bath was weak, and, if washed and dried at once without further treatment, became a hard, brittle mass which crumbled into a powder upon handling. In order to overcome this tendency, the fiber was cured or tanned by the well-known salt and formaldehyde solutions that have been successfully employed for many years by manufacturers of casein fibers and plastics [4, 13].

Yarn emerging from the acid coagulating bath was wrapped on the first set of delay rolls (*3*, on Figure 1) over which was running a formaldehyde solution maintained at 50° ± 1°C. This aqueous curing solution contained by weight 10 percent sodium sulfate, 10 percent aluminum sulfate, 5 percent formaldehyde, and 3 percent sulfuric acid. The speed of the delay rolls was such that a stretching of the extruded yarn through the bath was obtained. A second stretch of approximately 100 percent was introduced between the delay rolls and the first godet (*4*, on Figure 1). The fiber was then further cured on the second set of delay rolls (*5*, on Figure 1) with another solution maintained at 83° ± 1°C. This second curing solution contained 12 percent sodium sulfate, 10 percent aluminum sulfate, and 5 percent formaldehyde. The yarn was again stretched, this time about 150 percent between the second set of delay rolls and the third godet (*6*, on Figure 1). The over-all stretch was 470 percent based on a comparison of the linear rate of extrusion of the protein solution into the acid bath with the surface speed of the take-up bobbin (*7*, on Figure 1). The fiber was collected on the bobbin with as little tension as possible, so that the subsequently applied after-treating solutions could easily penetrate throughout the yarn on the bobbin.

After-Treatment

The yarn collected on the spinning machine, as a result of the short duration of treatment to which it was subjected, was still insufficiently cured for handling during textile-processing op-

erations. After-treatment in a final curing solution, however, increased the formaldehyde content from a value of 0.22 percent to at least 1.5 percent, and the resulting yarn could be handled. For convenience, this after-treatment of the yarn on the bobbin was applied for 16 hours, although a shorter period would have been sufficient.

Two bobbins of yarn were collected from each batch of protein solution spun. Both of these were cured for 16 hours at room temperature; one in an aqueous solution containing 2 percent hydrochloric acid, 20 percent sodium chloride, and 5 percent formaldehyde; and the other, in a sodium acetate buffer solution of pH 5.8 which also contained 5 percent formaldehyde. Each bobbin of yarn, upon removal from the curing solution, was washed free of salt and excess formaldehyde, and reeled into skeins. One skein was relaxed in water, and then dried at 50°C. Inasmuch as the hand of the yarn was often improved by oiling, another skein from each bobbin was oiled in a 0.5 percent solution of sulfonated castor oil at 50°C for ½ hour before drying at 50°C.

Method of Testing Fiber

Fibers made as described above were tested to determine their dry and wet tenacities and elongation after conditioning for 24 hours at 70°F and 65 percent relative humidity. The tests were performed on 10-inch samples of untwisted fiber on an IP-2 Scott tester with a 250-gram carriage. Wet tests were made by first immersing the samples in water for 20 minutes, after which they were removed and immediately tested for wet strength and elongation.

Experimental Data

Influence of pH and of Certain Chemicals in the Protein Solution

The amount of water, 2.4*N* sodium hydroxide, and other materials added to the protein solution before spinning are given in Table I. Also included are the serimetricals (dry and wet tenacity and elongation) of the yarns produced; for comparison the serimetricals of the oiled and unoiled yarns after-treated in both the chloride- and the acetate-buffer curing solutions are given. Best results were obtained when the pH of the spinning solution was approximately 12.0. Yarns spun from protein solutions of pH 11.5 and 12.5 lost considerable strength when oiled at 50°C for ½ hour. A fiber from a solution made up at pH 11.0 was too weak to be handled on the spinning machine. Plasticizers such as dibutyl tartrate, dibutyl phthalate, tritertiary amyl aconitate, and tributyl aconitate did not appreciably affect the serimetrical properties of the yarn. A tendency of the filaments to stick together when dried, one of the main difficulties encountered in the production of protein fiber from peanuts, was reduced by employing diethylene glycolmonolaurate (trade name, "diglycol laurate") in the protein solution with or without a refined vegetable oil. The yarn with the best strength and openness and the softest hand was spun from a protein solution containing dibutyl tartrate, diglycol laurate, and peanut oil.

Effect of Boiling the Fiber

Sarelon produced and cured with an aqueous solution of formaldehyde and salts such as sodium sulfate, aluminum sulfate, and acetate buffer is sufficiently strong and flexible to withstand textile processing. On boiling or on dyeing under normal conditions, however, the yarn becomes plastic; its strength is destroyed; and upon subsequent drying it becomes a horny mass. These tendencies can be overcome to some extent by further treatment with anhydrides and ketones [7] or with formaldehyde and gaseous sulfur dioxide [7]. A simpler process that does not involve additional treatment after curing is one in which the yarn is cured after removal from the spinning machine in an acid aqueous solution containing halide ions, metal ions, and formaldehyde [7].

One bobbin of yarn from each experiment was treated in the solution containing 2 percent hydrochloric acid, 20 percent sodium chloride, and 5 percent formaldehyde. Another specimen of yarn that had been after-treated in sodium acetate buffer at pH 5.8 and with 5 percent formaldehyde was acetylated with acetic anhydride for 1 hour at 100°C.

In order to test the yarns treated by the two above-mentioned methods for boil-resistance under conditions simulating those in an acid dye bath, skeins were placed in beakers containing 200 milliliters of water per 4-gram skein, to which was added 0.312 gram of sodium sulfate per gram of yarn. This solution was taken to the boiling point in 15 minutes, 0.15 milliliter of 56-percent acetic acid per gram of yarn was added, and fiber and solution were held at the boil and skeins were removed periodically. Upon removal from the boiling solution, the yarn was dried

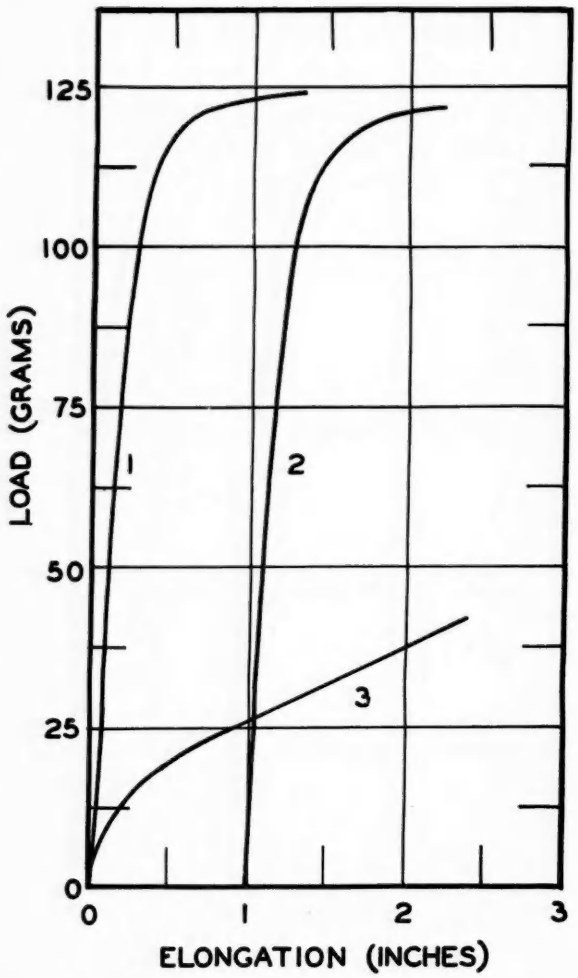

FIG. 2. *Load-elongation curves—total break. Ten-inch samples of 200-denier, 40-filament yarn tested for total break on an IP–2 Scott tester using a 250-gram carriage. End of curve denotes where break occurred. 1—Dry test, 2—knot test, and 3—wet test.*

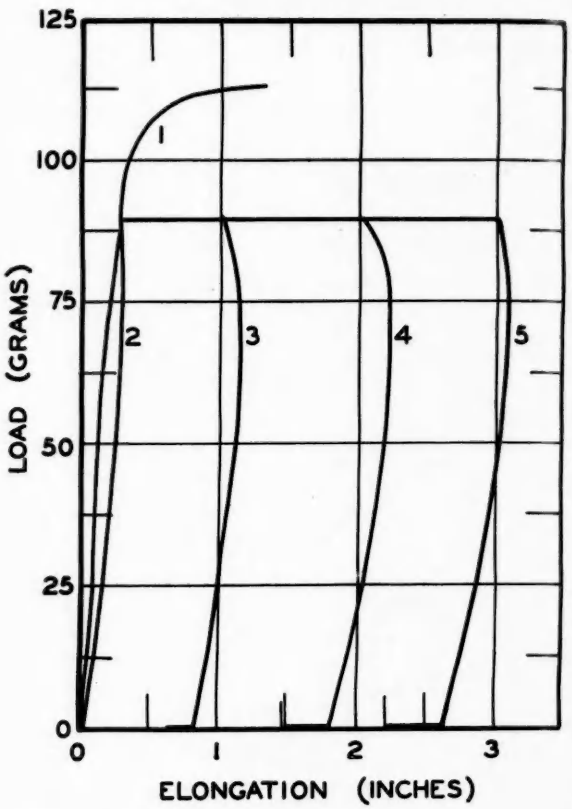

FIG. 3. *Load-elongation curves—elastic recovery. Ten-inch samples of 190-denier, 40-filament yarn tested for elastic recovery on an IP–2 Scott tester using a 250-gram carriage. End of curve denotes where break occurred and arrow denotes the recovery at the end of 3 minutes. 1—Normal stress-strain curve; 2—yarn loaded up to 80 percent of breaking load and load then immediately reduced to zero; 3—yarn loaded to 80 percent of breaking load, elongated 10 percent, and load then reduced to zero; 4—yarn loaded to 80 percent of breaking load, elongated 20 percent, and load then reduced to zero; 5—yarn loaded to 80 percent of breaking load, elongated 30 percent, and load then reduced to zero.*

at 50°C, conditioned for 24 hours at 70°F and 65 percent relative humidity, and tested for dry and wet strengths and elongations. Skeins of the yarn that had been after-treated in sodium acetate buffer and formaldehyde were removed from the solution at the beginning of the boil and at 5, 10, 15, 30, and 60 minutes after the solution reached the boiling point. Skeins of the yarn subjected to treatment in the chloride-formaldehyde bath were removed at 30, 60, and 90 minutes after boiling started.

Table II gives the serimetricals of all these boiled yarns. It is noted that in all cases boiling decreased the dry and wet strengths and elongations. Acetylation decreased the dry strength and elongation and did not produce a yarn with as good a boil-resistance as did the chloride after-treatment. As much dry strength was lost by the acetylated yarn merely by taking it to the boiling point as had been lost by the chloride-treated yarn after 1½ hours of boiling.

Stress-Strain Curves

The stress-strain curves of a 200-denier, 40-filament yarn are shown in Figure 2. These curves, as produced by the IP-2 Scott tester employing a 250-gram carriage and a 10-inch sample between jaws, are: (1) dry test, (2) knot test for flexibility, and (3) wet test.

TABLE II. EFFECT OF BOILING PEANUT-PROTEIN FIBER ON DRY AND WET STRENGTH AND ELONGATION OF THE FIBER*

Experiment No.	Treatment	Time of boiling†	Strength (g./den.) Dry	Strength (g./den.) Wet	% Elongation Dry	% Elongation Wet
237 (control)	Treated in 20% NaCl, 2%HCl, 5% CH_2O for 16 hrs. at 25°C	None	0.59	0.16	16.8	34.0
237-9	Same as for No. 237	½ hr.	0.60	0.12	4.3	28.0
237-10	Same as for No. 237	1 hr.	0.56	0.11	3.3	33.0
237-11	Same as for No. 237	1½ hrs.	0.48	0.09	3.3	29.1
246 (control)	Treated in NaAc buffer 5% CH_2O for 16 hrs. at 25°C	None	0.67	0.18	11.8	25.5
246-1	No. 246 acetylated at 100°C for 1 hr.	None	0.59	0.18	5.3	31.5
246-2	Same as for No. 246-1	Start to boil	0.48	0.12	3.8	34.4
246-3	Same as for No. 246-1	5 min.	0.38	0.10	3.1	37.0
246-4	Same as for No. 246-1	10 min.	0.30	0.08	2.2	22.3
246-5	Same as for No. 246-1	15 min.	0.24	0.08	1.6	26.0
246-6	Same as for No. 246-1	30 min.		too weak to test		
246-7	Same as for No. 246-1	60 min.		too weak to test		

* All tests made under standard conditions of 70°F and 65 percent relative humidity; sample conditioned for 24 hours. IP-2 Scott tester employed with 250-gram carriage, and 10-inch sample used between jaws. Results are average of 10 tests.
† Samples boiled in an aqueous solution containing 0.312 gram of sodium sulfate and 0.15 ml. of 56 percent acetic acid per gram of fiber. 200 ml. of water used per 4-gram skein.

Sarelon has a rather high modulus of elasticity and exhibits very little elongation until 85 to 90 percent of the total breaking load has been applied. Plastic flow then appears to set in and the yarn flows to a break. According to the stress-strain curves, this yarn should have a low wear-resistance. When blended with other fibers, however, it is not likely that the over-all resistance to abrasion would be appreciably impaired.

Elastic Recovery

Although Sarelon has a low elongation up to 90 percent of the full breaking load, it will nevertheless creep. When the load is removed Sarelon has the ability to regain part of this elongation. To determine the ability of this fiber to recover from creep elongation, the yarn was loaded to 80 percent of its breaking load, and the tension was decreased to zero after elongating to 3, 10, 20, and 30 percent of its original 10-inch length. Results of these tests are represented in Figure 3 by stress-strain curves and are summarized in Table III. Recovery was measured immediately on return of the tester carriage to zero load and 3 minutes after relaxation of the stress.

TABLE III. ELASTIC RECOVERY OF THE PEANUT-PROTEIN FIBER LOADED TO 80 PERCENT OF TOTAL BREAKING LOAD AND ELONGATED 10, 20, AND 30 PERCENT

Percent elongated under 80% load	Time of elongation	Percent recovery immediately	Percent recovery at end of 3 minutes
3	—	75	100
10	38 sec.	27	44
20	50 sec.	18	32
30	66 sec.	14.5	29

Although the elastic recovery decreased with increasing amounts of creep, all yarns returned to their original length when placed in water and redried. The redried samples when again loaded and elongated did not show appreciable differences in their elastic-recovery properties, which appears to indicate that loading and unloading had not severely damaged the yarn.

Moisture Regain

To determine the amount of moisture absorbed by the fiber under standard conditions of 70°F and 65 percent relative humidity, the conditioned yarn was weighed and was heated at 225°F to constant weight. The calculated regain was approximately 15 percent.

Effects of Dry Heat and Carbonization

Inasmuch as synthetic protein yarns have found uses in wool blends, the effects of carbonization (heat and acid) as applied to woolen pieces and of heat alone were determined. The yarn that had been employed for the determination of moisture regain, after being conditioned at 70°F and 65 percent relative humidity for 24 hours, was tested before and after heating. Table IV shows the effect of heating to 107, 140, and 180°C on the dry and wet strengths and elongations of the yarn.

During the heating process, the yarn lost some formaldehyde and became slightly more yellow.

Heating, however, did not affect the hand of the yarn and appeared slightly to increase its dry and wet strength. Its flexibility was decreased only slightly.

In another test 5-gram skeins of the same yarn which had been wetted with water were immersed in a $\frac{1}{100}$ carbonizing bath containing 3 percent sulfuric acid and agitated occasionally for 15 minutes. The skeins were removed from the bath and pressed between sheets of blotting paper, dried for 20 minutes at 71°C, and heated to 113°C for 15 minutes. The skeins were then immersed in a 1-percent solution of sodium carbonate to neutralize the acid, rinsed, and dried at 50°C. The effects on the strength of the yarn treated in this manner were practically identical with those shown in Table IV for the treatment by heat alone.

Summary

1. The production and properties of Sarelon, a peanut-protein fiber, are described (see Figure 4).

2. An apparatus with multiple baths, allowing the spun fiber to be stretched and strengthened, has been designed for use in the production of fibers from peanut proteins.

3. Diglycol laurate in small amounts with or without oils in the spinning solution increased the openness and improved the hand of the fiber.

4. Acetylation at 100°C for 1 hour with acetic anhydride did not produce adequate boil-resistance. After-treatment, however, in 2 percent hydrochloric acid, 20 percent sodium chloride, and 5 percent formaldehyde did produce good boil-resistance. Even after 1½ hours of boiling the fiber had considerable strength.

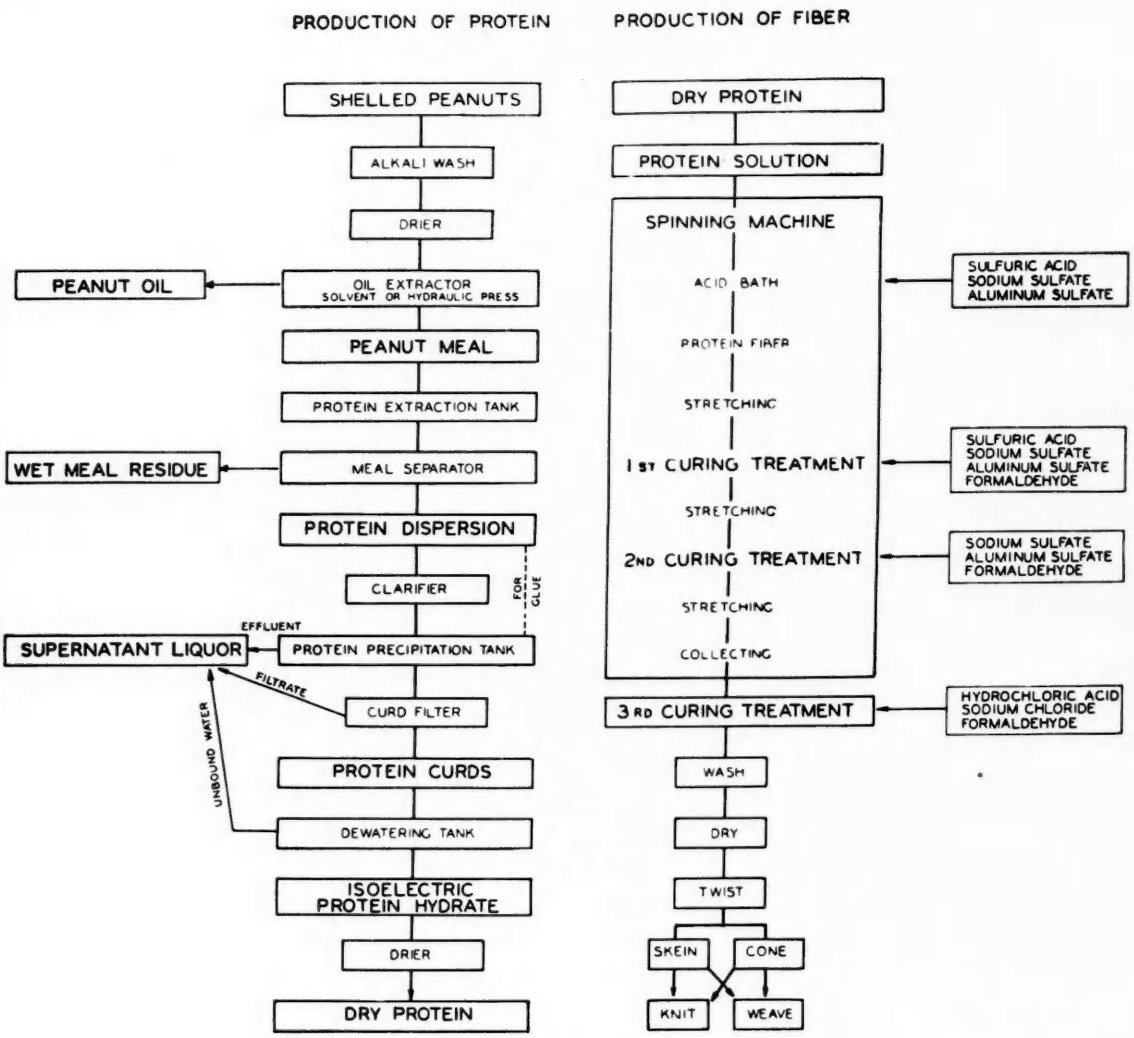

FIG. 4. *Schematic outline of production of peanut protein fiber.*

TABLE IV. THE EFFECT OF HEATING THE YARN TO 107°, 140° AND 160°C ON THE DRY AND WET STRENGTHS AND ELONGATIONS OF THE FIBER*

Sample No.	Before heating: Strength (g./den.) Dry	Wet	% Elongation Dry	Wet	Treatment: Heated in oven Temp.	Time	After heating: Strength (g./den.) Dry	Wet	% Elongation Dry	Wet
259-1	0.64	0.16	13.2	27.2	107°C	1 hr.	0.64	0.18	16.7	24.2
259-2	0.63	0.17	7.0	27.5	107°C	3 hrs.	0.68	0.19	7.0	26.0
259-3	0.64	0.17	9.1	27.6	107°C	5 hrs.	0.69	0.19	9.0	27.0
259-4	0.63	0.16	13.8	24.8	140°C	1 hr.	0.68	0.21	13.8	23.0
259-5	0.64	0.17	7.7	26.5	140°C	3 hrs.	0.69	0.23	16.7	23.5
259-6	0.61	0.17	9.5	26.3	140°C	5 hrs.	0.69	0.22	10.6	23.4
259-7	0.62	0.17	7.9	27.5	108°C	15 min.	0.70	0.22	10.0	21.5
259-8	0.64	0.18	9.6	26.9	108°C	30 min.	0.71	0.23	8.0	23.0

* Yarn conditioned at 70°F and 65 percent relative humidity for 24 hours. Tested on an IP-2 Scott tester with a 250-gram carriage, 10-inch sample employed. Results are average of 10 tests.

5. Heating of the fiber which had been treated in 3-percent sulfuric acid solution to carbonizing temperatures, as is done in the woolen industry, has no detrimental effect on its physical properties.

6. The fiber has the ability, within limits, to regain elongation caused by creep and to return to its original length upon wetting and redrying.

7. With suitable selection of dyes the fiber may be dyed by acid, vat, direct, and acetate dyes.

8. The best fiber was produced when dibutyl tartrate, diglycol laurate, and oil were employed in the protein spinning solution and when the resulting fiber was after-treated in a solution of sodium chloride, hydrochloric acid, and formaldehyde. This fiber had a dry strength of 0.67 gram per denier, a wet strength of 0.18 gram per denier, and dry and wet elongation of 11.8 and 22.0 percent, respectively.

Acknowledgment

The authors are indebted to members of the Analytical, Physical Chemical, and Physical Division for analysis of the fiber and of the solutions employed, and to the Cotton Processing Division for the physical measurements of the yarns. They also wish to express their appreciation to R. S. Burnett for many helpful suggestions.

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Mechanical Properties of Textiles, IX*

A System Showing a Distribution of Non-Newtonian Viscous Elements

Sidney Katz,† George Halsey,‡ and Henry Eyring**

Contribution of The Textile Foundation and Princeton University, Frick Chemical Laboratory, Princeton, New Jersey

THE use of any sort of model containing more than one viscous element is a difficult undertaking. However, the most rudimentary considerations of the molecular structure of a fiber make it seem highly unlikely that the fiber can be described with a single viscous element, no matter how involved its law of operation. Nevertheless, a single element serves to a remarkable degree to reproduce the behavior of materials which do not exhibit plastic flow to an appreciable extent.

The "distribution" used here contains only two elements; no particular significance, however, can be attached to this, except perhaps that the data do not warrant further extension. The actual fiber, no doubt, involves a continuous distribution.

It is necessary to remark that the distribution used here has nothing in common with the Wiechert distribution of linear elements; this latter is totally inadequate to explain the experiment. It is much farther from the facts than the three-element, non-Newtonian model.

In the analysis of a large number of stress-strain curves, using the method of the three-element model of previous papers, certain persistent difficulties have been encountered. The curve of Figure 1 shows an extreme case. The ultimate slope is well defined. Therefore, simple permanent set cannot be a factor over moderate time ranges. Repeated cycles could then be expected to yield a limiting curve (one of the criteria of Paper VIII).

In order to place the line of ultimate relaxation, three procedures are resorted to, using the well-defined ultimate slope. First, the line is drawn from the origin. This is unsatisfactory for two reasons: first, the line does not cut the experimental curve with constant angle and, second, it does not agree with the position of ultimate relaxation as determined at the end of the experiment.

An attempt to draw a line through the points of constant slope meets with even less success. Using the established slope, it is impossible to go through all of the points. The line is too high for the relaxation curve, and, of course, it fails completely to agree with the determination of the point of ultimate relaxation. Projecting the line back from this point

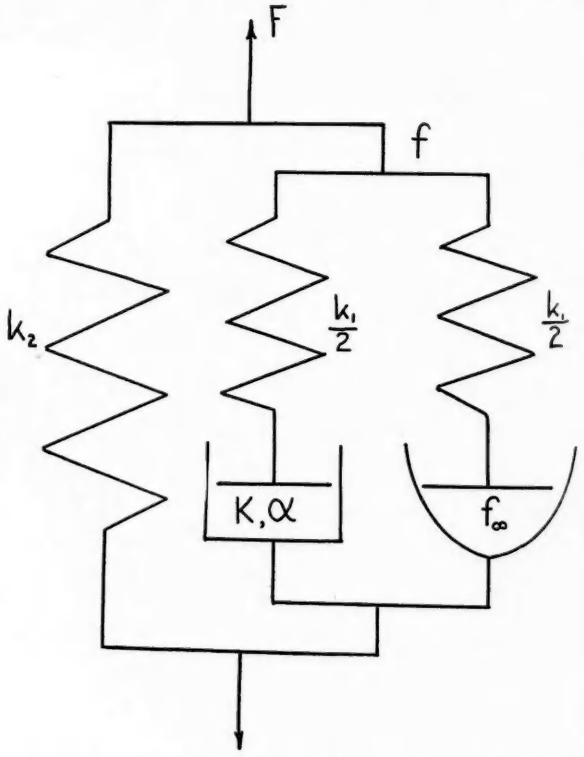


FIG. 2. *The five-element model used in this paper to explain the curve of Figure 1.*

* This is the ninth paper in the series "The Mechanical Properties of Textiles." The previous papers were published in the September and December, 1945, and the January, February, March, May, and July, 1946, issues. Paper X follows, in this issue, page 382.

† A part of Mr. Katz's Junior Independent Work consists of his contribution to this paper.

‡ Fellow of the Textile Research Institute.

** Director of Fundamental Research, The Textile Foundation.

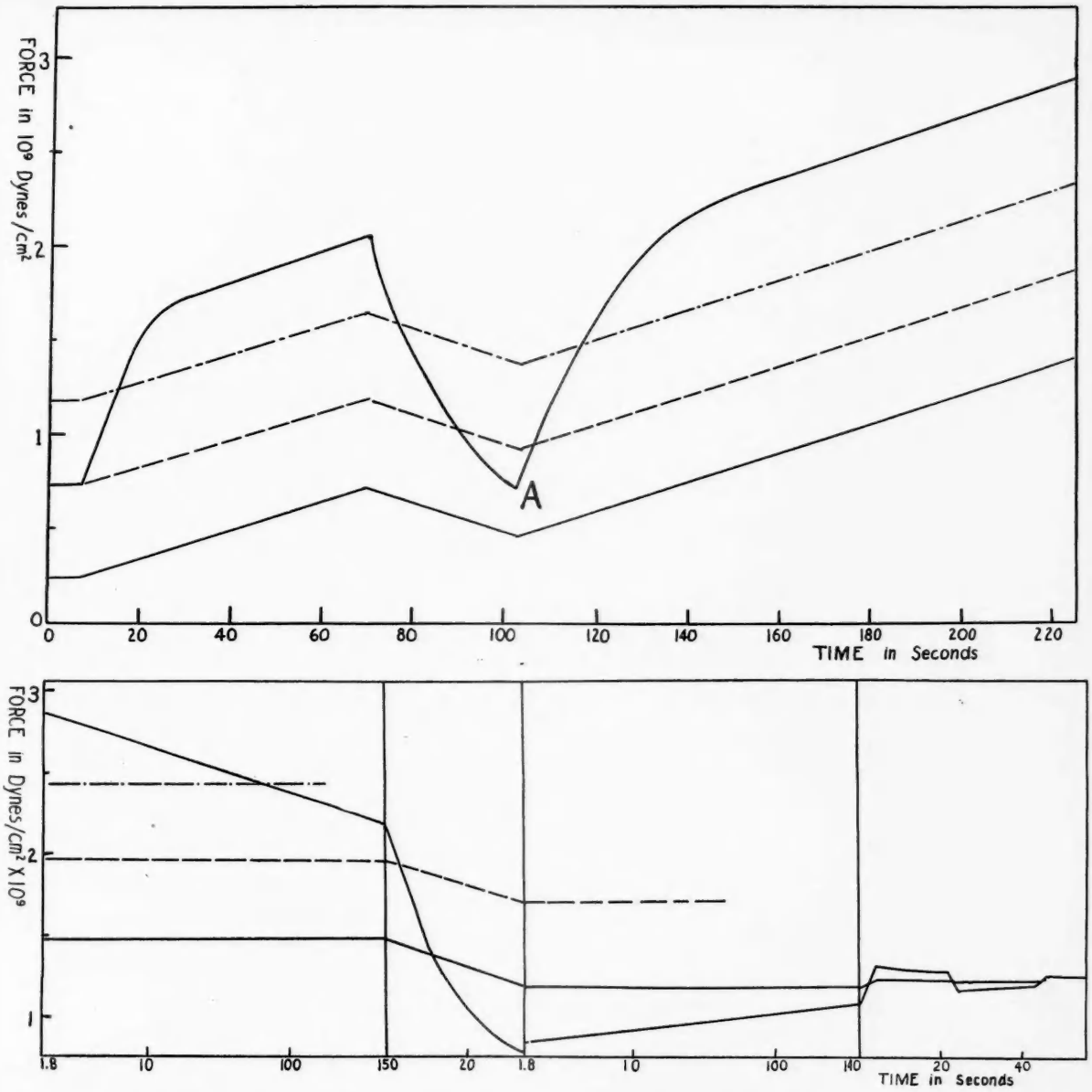
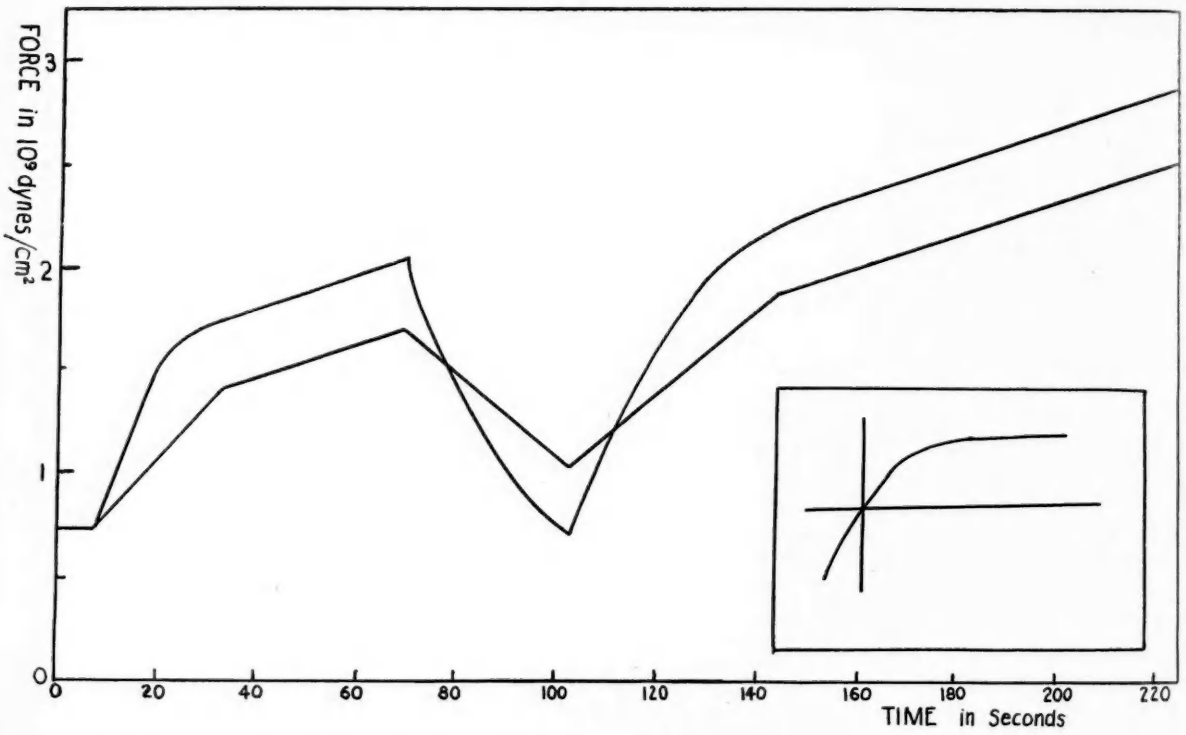


FIG. 1. *A typical stress-strain curve showing the inadequacy of the three-element model. It is 6-denier textile rayon, elongated at a rate* 6.5×10^{-4} *per second at 0.35 R.H.*

also fails completely. It leaves the point *A*, which is obviously a point below the spring, hopelessly above it.

These considerations obviously lead to the conclusion that the model is not a correct picture of this fiber. However, the qualitative aspects of the diagram are the same as a curve produced by a perfect three-element model. No widely separated processes exist. The sharpness of the initial yield point completely disallows a wide distribution of yield forces of a simple non-thixotropic character. These yield forces must be within perhaps 10 percent of one another. Equally impossible is any type at all of three-element model. A single dashpot, even if unsymmetrical and thixotropic, cannot explain point *A*. That is, a true point of ultimate relaxation cannot always be achieved by finite process.

The model suggested by these considerations is one containing a number of elements of the same yield strength. A simple model of this type suffices to explain the curve in Figure 1. This model (Figure 2) contains two dashpots of equal yield value.



One is quite non-Newtonian and the other is more nearly Newtonian. The effect of this arrangement is that the non-Newtonian dashpot reinforces the spring when it is not at the yield force. When the point of ultimate relaxation is found by hunting, it does not represent the place where the force on the compound element is zero, but the place where the force on the Newtonian dashpot is zero. Therefore, the slope to be used in leaving this point to connect with other similar points is not the well-defined slope but a steeper slope calculated by connecting several points of the proper slope. This slope must yield to the well-defined slope when the yield value is reached. That this model accounts for the curve is apparent (Figure 3). During the relaxations, the model must be abandoned in favor of a smoother distribution of some unknown character. At a finite rate, however, this crude model is the most that can be justified. Its importance is that it is the *simplest* model that possibly can give rise to the experimental facts.

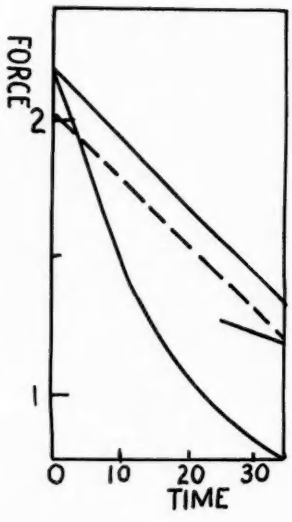


FIG. 3. *The curve of Figure 1 here is analyzed on the basis of the model of Figure 2. Only a small excerpt from the second part of Figure 1 is shown.*

Concerning the Calculation of the Constants

When the force is divided among several viscous elements, there are at least two ways to express the constants. If the actual force on an element is used to compute the constant, then this represents the exact mechanical element that would reproduce the behavior when combined with its fellow springs and dashpots. However, if constants are based on the total viscous force along with a "concentration," then the situation is conceptually clearer. Thus, if a person wished to make a three-element model with two identical dashpots instead of one, it seems desirable that the constants should be the same as if he had used only one because the behavior would be identical.

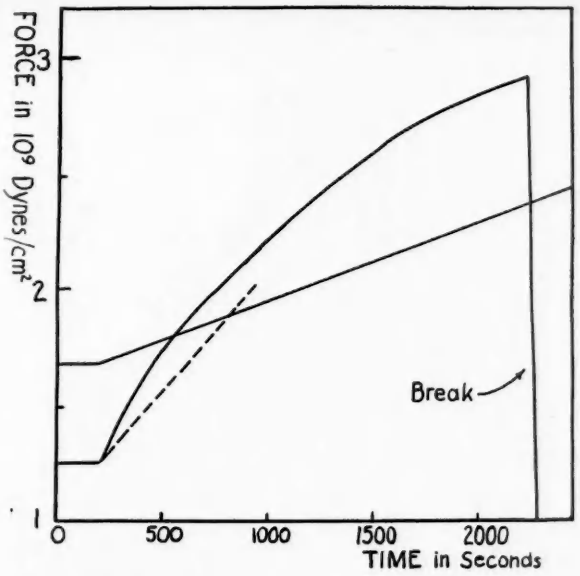


FIG. 4. *The experiment of Figure 1 carried out at one twenty-fifth the former rate. It shows the presence of a distribution but is interrupted by breakage of the fiber.*

The Effect of the Rate of Elongation

So far as a single rate of elongation is concerned, the model of Figure 2 seems quite adequate. Figure 4 shows the effect of changing the rate of elongation to one twenty-fifth of its former value. Unfortunately, the fiber soon broke. The shape of the curve, however, shows that the hypothesis of equal yield forces is no longer good. The presence of a distribution of relaxation times is clearly indicated. This is as it should be, for if at one speed the yield force of the dashpots is equal, then at other speeds the yield forces must diverge from one another. Figure 4 shows that the dashpot of the more Newtonian character is almost completely yielded at all times, and that the yield force is approximately accounted for by the completely non-Newtonian dashpot, if that yield force, by hypothesis, is considered constant.

The gradual nature of the yielding process shows that this hypothesis is only qualitatively correct, and that the completely non-Newtonian dashpot is beginning to split into several more or less non-Newtonian dashpots.

Calculation of the Constants for the Figure

Proceeding in a manner similar to that described in Paper III of this series, and observing the convention explained in the note on the calculation, one obtains the following results:

Springs: $k_1 = 0.94 \times 10^{11}$ dynes/cm^2
$k_2 = 1.19 \times 10^{10}$ dynes/cm^2

First dashpot: 0.66 concentration

$f_\infty = 0.874 \times 10^9$ dynes/cm^2

Second dashpot: 0.34 concentration

$\rho = 6.5 \times 10^{-4}$
$\beta = 3$ (from shape)
$\kappa = 2.2 \times 10^{-4}$
$\alpha = 2.09 \times 10^{-9}$
$\Delta F^{\ddagger} = 23{,}650$ calories
$V_h = 5.5$ Å cubed

In Figure 3, second part, the agreement with the established line of no relaxation is shown by the difference between the dashed line and the solid line. In Figure 4, the dashed line gives the slope used before to represent the single dashpot. At this new speed, it is no longer meaningful.

Mechanical Properties of Textiles, X

Analysis of Steinberger's Data on Creep of Cellulose Acetate Filaments

C. H. Reichardt,* George Halsey,* and Henry Eyring †

Contribution of The Textile Foundation and Princeton University, Frick Chemical Laboratory, Princeton, New Jersey

I. Introduction

The first paper [1] of this series developed the theory of the three-element model, which subsequently was applied in the sixth paper [2] to the creep of viscose rayon, cotton, and wool. R. L. Steinberger [3] determined the creep of single fibers of cellulose acetate, at room temperatures, stressed with constant load at eleven relative humidity values, ranging from 0 to 100 percent. The object of this paper is to explain his results on the basis of the theory of the three-element model.

Consideration of the mechanical properties of a fiber based on the three-element model gives rise to a creep curve of three distinct parts, as shown in Figure 1. The first two parts of the curve, *OA* and *AB*, correspond to the direct action of the three-element model under discussion and can be explained on the basis of either form of this model as given in Figure 2. Both forms are equivalent, as can be seen. However, creep can be explained most conveniently by form *B*, which is the form on which all theoretical calculations in this paper will be based. In light of the work that has gone before in this series, it appears to be advantageous here to explain creep in terms of both forms of the three-element model.

Consider Figure 1 on the basis of the model given in Figure 2A. The first section of the curve, *OA*, which occurs practically instantaneously on application of the load to the fiber, is attributed to the elongation of the springs s_1 and s_2, the limit of which is the limit of elongation of the two springs at that load, and the experimental manifestation of which is the observance of the initial elongation at the shortest time at which it is possible to take the first reading after application of the load. During this part of the curve, the dashpot, d_1, has not yet moved.

In the region of the second part of the curve, *AB*, the dashpot is flowing, restrained by the spring s_2, until elongated to the length *b*, corresponding to the point *B*, which is the limit of elongation of the spring s_2 at that load. During this period, the spring s_2 is still elongating, the force on spring s_1 is decaying, until the upper limit is reached, where there is no force on either the spring s_1 or the dashpot d_1, and all the force is on the spring s_2. The part *BC* of the curve apparently corresponds to pure viscous flow as represented by a single dashpot, which is unrestrained by a spring and which takes place up to the point of autocatalytic break. This third region is probably the result of a gradual lengthening of the elements of the fiber.

If the curve is considered on the basis of the second form of the model as shown in Figure 2B, it is seen that the first part of the curve, *OA*, owing to instantaneous elongation of the spring *s'* under the influence of the load, the dashpot d_1, as before, has not yet moved. In the second part of the curve *AB*, the dashpot is now flowing, the spring *s* is elongating, and the force on the spring s_1 is remaining constant, until the upper limit corresponding to the elongation *b*, which is the limit of elongation of the two springs at that load, is reached. The remainder of the curve *BC* remains as before. The important portion of the experimentally observed creep curve is thus the portion *AB*, which can be attributed to the inherent properties of the fiber.

Steinberger's data were replotted in Figure 3, on a log time scale with the time expressed in seconds. The origins for curves 12, 13, 14, and 15 were moved down on the ordinate scale, as shown, to avoid confusion of points, as these curves lie very close together. The points in Figure 3 correspond to points given in Steinberger's paper, arrows indicate fiber rupture, and the solid lines are theoretical. When all of the curves are plotted on one ordinate and abscissa, it is evident from a cursory examination

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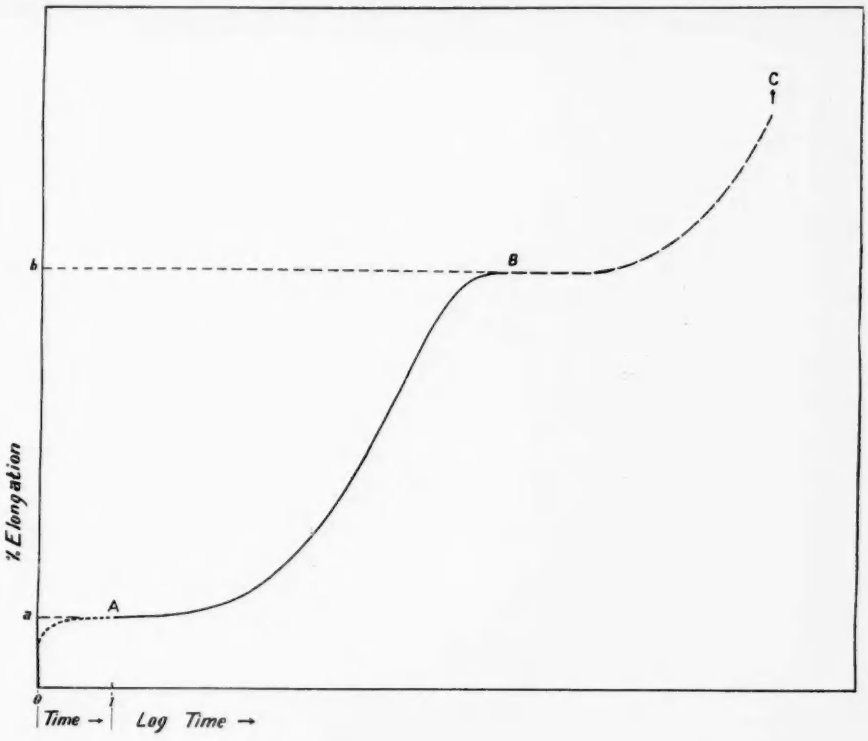

FIG. 1. *Hypothetical creep curve.*

that the curves form a regular series, as would be expected on the basis of the three-element model.

It is noted that point A, the elongation of spring s', is practically constant for all relative humidities, and at the same time the fibers appear to be approaching the same elongation corresponding to point B in Figure 1, which would correspond to a constant limit for the two springs s and s' for that particular load. Again, also in accordance with theory, it is noted that as the relative humidity decreases, the dashpot appears to become stiffer, as is shown by the increase in the length of time that elapses before the curve starts upward with decreasing relative humidity.

On examination, the limitations of this particular set of data are apparent. First, the load was too great for measurement of the creep at high relative humidities; in fact, Steinberger noted that in Series 1 the fiber broke as soon as the load was placed on the fiber in the 90 percent relative humidity experiment, and in Series 2, recorded in Figure 3, the 90 percent relative humidity run is undoubtedly well beyond the portion of the creep curve owing to the three-element model.

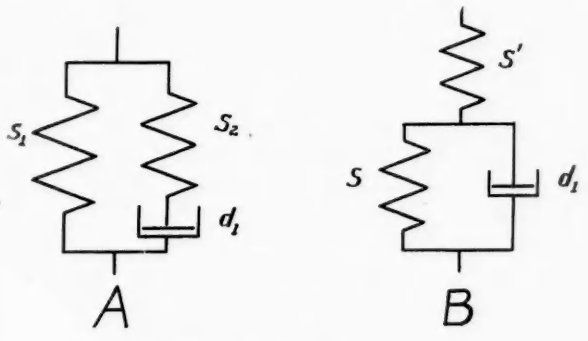

FIG. 2. *Three-element model.*

Second, because of the stiffness of the dashpot at low relative humidities, the load was too small to measure creep in reasonable lengths of time, as it is obvious that the creep curves for the runs at relative humidities of 0 to 50 percent have hardly started. Thus, for complete analysis of the data, it would have been necessary to continue the experiments for another 10–15 cycles of log time, which was obviously impractical. Moreover, it would have been helpful if several series of experiments at greater and lesser loads had been carried out in order to cover the range of humidities more adequately.

II. Theoretical Analysis of Steinberger's Data

A. Integrated Equation for the Creep Curve

In Section IV-C of Paper I [1] the integrated equation for the relaxation of stress at constant elongation was derived. An analogous equation for the creep of a fiber at constant load can be derived by a similar treatment, as given in Paper VI [2]. The equation, governing creep, in its final reduced form is

$$\log\left\{\frac{\tanh\dfrac{\alpha(1-l)}{2}}{\tanh\dfrac{\alpha}{2}}\right\} = t\log\left\{\frac{\tanh\dfrac{\alpha}{4}}{\tanh\dfrac{\alpha}{2}}\right\}. \quad (1)$$

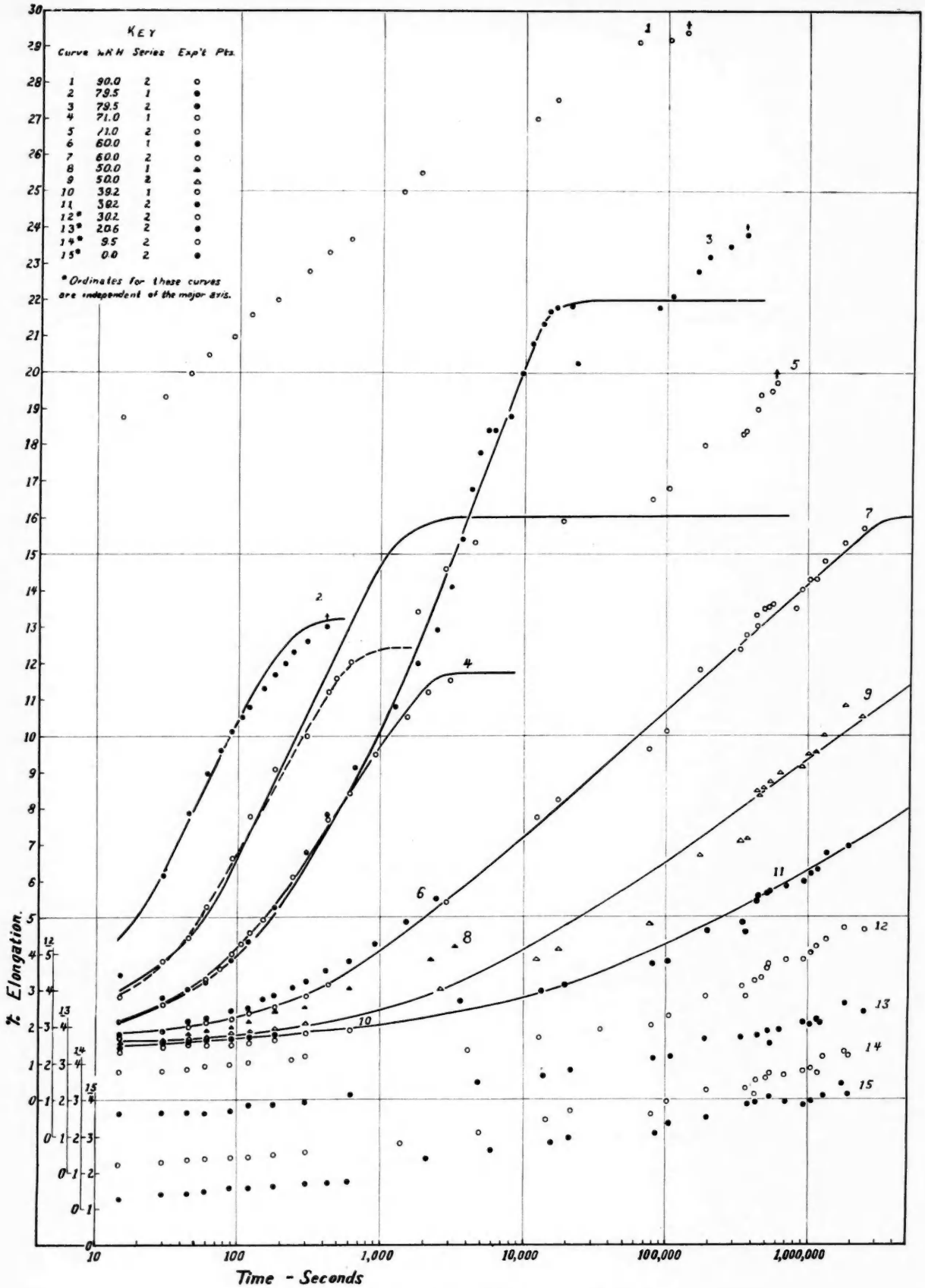

FIG. 3. *Steinberger's data replotted and fitted.*

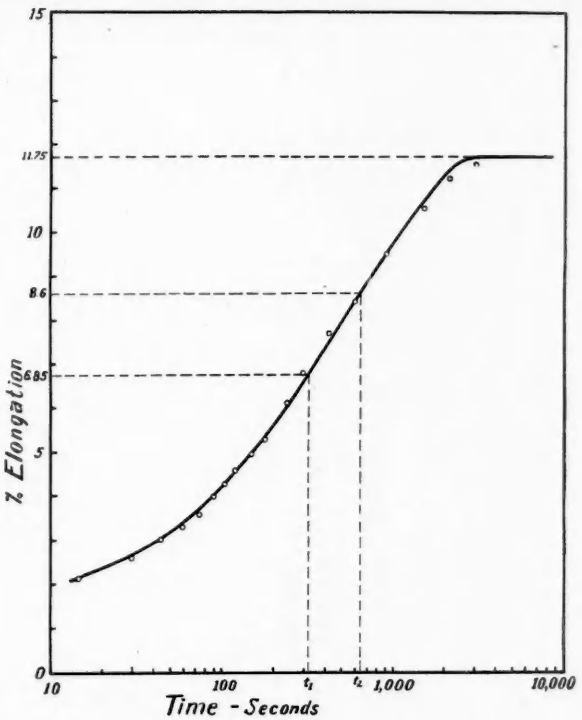

FIG. 4. *Method of fitting experimental data.*

This equation governs that portion of the total creep curve designated in Figure 1 as curve *AB*. All calculations for the curves which are based on the above reduced form of the equation must be made by taking the point *A* to be zero on the ordinate scale, the abscissa (log time) scale remaining the same.

III. Method of Analysis

Figure 4 consists of curve 4, Figure 3, corresponding to the run at 71 percent relative humidity, Series 1, taken from Steinberger's data to show the method of analysis. Examination of the data shows that the curves—at least those for 60.0, 71.0, and 79.5 percent relative humidity—are converging on the elongation 1.75 percent at zero time. This would correspond to the elongation of the spring *s'* for that load, and is the zero point for analysis of this section of the total creep curve. Again the curve is approaching the elongation 11.75 percent asymptotically, corresponding to the total elongation of the springs *s* and *s'* for that load. The total percentage elongation for spring *s* is thus 10.0 percent and the point at which the fiber has been elongated half this distance is thus at the point 5.0 + 1.75 = 6.75, corresponding to time, $t_1 = 320$ seconds. The elongation at twice this time, $t_2 = 640$ seconds, is 8.55 − 1.75 = 6.8, taken from the experimental data.

From the method of Paper I, the reduced force, f_2, acting on the dashpot, is given by

$$f_2 = 1 - \frac{6.8}{10.0} = 0.32.$$

Then from the function for the log tanh creep law, which is given in Figure 5 and calculated from equation (1) with the value of f_2 at $t = 2$ when $f_1 = \frac{1}{2}$ at $t = 1$,

$$\log \left\{ \frac{\tanh \frac{\alpha f_2}{2}}{\tanh \frac{\alpha}{2}} \right\} = 2 \log \left\{ \frac{\tanh \frac{\alpha}{4}}{\tanh \frac{\alpha}{2}} \right\}, \qquad (2)$$

$$\alpha = 3.0.$$

Then, using equation (1), the above value for α, the theoretical creep curve can be calculated, as given by the solid lines in Figures 4 and 3, which agree with the experimental data.

Steinberger's data give the following information: the load used was 2 grams per fiber, and the acetate used was 150-denier, 40-filament yarn. The load, a, on the fiber is then calculated to be 0.62×10^9 dynes/cm^2. The various constants of the three-element model can then be calculated from the following equations:

$$\alpha = \frac{\alpha_{\text{red}}}{a}. \qquad (3)$$

The spring constant k of the spring s is given by

$$k = \frac{a}{e}, \qquad (4)$$

where e is the elongation represented by the distance from points a to b in Figure 1.

The spring constant k' of the spring s_1 is given by

$$k' = \frac{a}{e_1}, \qquad (5)$$

where e_1 is the elongation of the spring s', represented by the elongation a in Figure 1.

The rate constant, K, of the dashpot d_1 is given by

$$K = \frac{b}{\alpha k}, \qquad (6)$$

where

$$b = \log \frac{(\tanh \alpha/4)}{(\tanh \alpha/2)}.$$

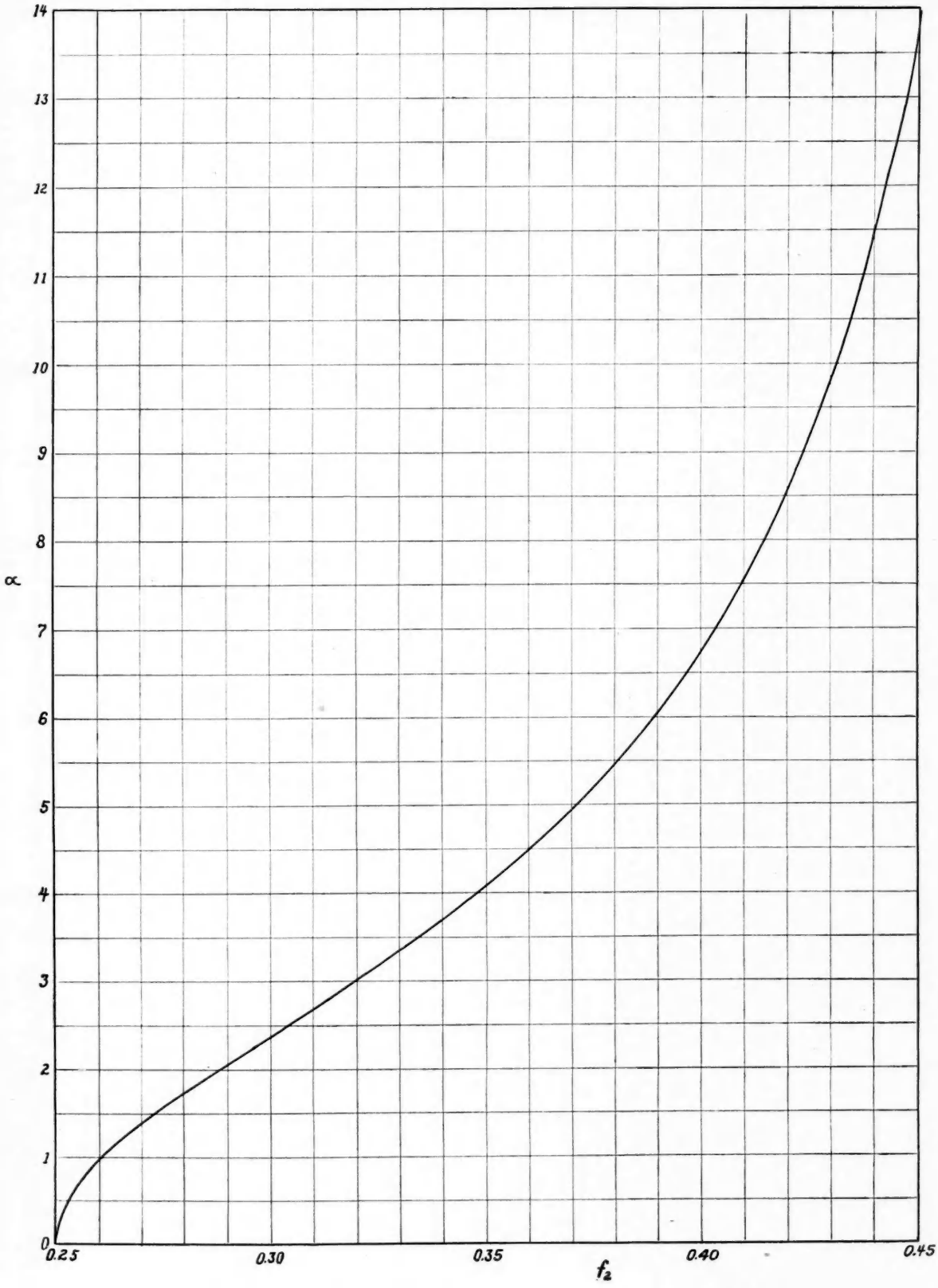

FIG. 5. *Function for the log tanh creep and relaxation law.*

TABLE I.

Curve	R.H. (%)	Series	a (dynes/cm²)	α (red)	α (cm²/dyne)	k (dynes/cm²)	k' (dynes/cm²)	K (per sec.)	Vf (Å cubed)	$\Delta F^{\ddagger}$ (cal.)
2	79.5	1	0.62×10^{9}	2.3	3.87×10^{-9}	5.38×10^{9}	3.54×10^{10}	4.85×10^{-4}	6.8	22,100
3	79.5	2	0.62×10^{9}	4.0	6.54×10^{-9}	3.08×10^{9}	3.54×10^{10}	3.1×10^{-5}	8.1	21,000
4	71.0	1	0.62×10^{9}	3.0	4.84×10^{-9}	6.2×10^{9}	3.54×10^{10}	3.75×10^{-5}	7.2	23,600
5 (solid)	71.0	2	0.62×10^{9}	3.0	4.84×10^{-9}	4.35×10^{9}	3.54×10^{10}	5.89×10^{-5}	7.4	23,400
5 (dashed)	71.0	2	0.62×10^{9}	2.3	3.87×10^{-9}	5.76×10^{9}	3.54×10^{10}	1.07×10^{-4}	6.8	22,800
7	60.0	2	0.62×10^{9}	9.4	1.52×10^{-8}	4.35×10^{9}	3.54×10^{10}	8.79×10^{-9}	10.7	29,800
9	50.0	2	0.62×10^{9}	12.0	1.93×10^{-8}	4.35×10^{9}	3.76×10^{10}	9.26×10^{-11}	11.7	31,300
11	39.2	2	0.62×10^{9}	14.0	2.26×10^{-8}	4.35×10^{9}	4.13×10^{10}	1.68×10^{-12}	12.3	33,700

The volume, V_f, of the flow unit is given by

$$V_f = 2k_oT\alpha, \tag{7}$$

where k_o is the Boltzmann constant.

The force energy of activation $\Delta F^{\pm}$ is given by

$$\Delta F^{\pm} = RT \ln \frac{2}{K} \frac{V_h}{V_f} \frac{k_0T}{h}, \tag{8}$$

where V_h is the volume of the hole swept out by the motion, V_f is the volume of the flow unit, assuming

$$\frac{V_h}{V_f} = 0.5.$$

Using the above method, the experimental curves were fitted and the values for the various constants were calculated as given in Table I.

IV. Discussion of Results

Steinberger plotted his data on various ordinate scales and wherever possible connected his points with two or more connecting straight lines; a few did not connect. He also pointed out that although the slope of the straight lines which he obtained appeared to increase with time, in the case of the curves obtained at high relative humidities the slopes started out by increasing with time but ended by decreasing. It must be noted that he could not connect all of his points by straight lines as successfully as the theoretical curves obtained on the basis of the three-element model fit the experimental data. Conceivably, it is possible to connect the experimental points, as Steinberger did, with straight lines, the slopes of which would increase or decrease with time in this manner, but there is no theoretical basis for so doing. Steinberger also stated that the straight lines appear to be consistent, and, in spite of the obvious irregularities, apparently indicate something fundamental in the behavior of the fibers. Inspection of the theoretical curves based on the three-element model leads to the realization that some portions of these curves consist of straight or nearly straight lines and that, naturally, some would be expected. But unless these are connected with the present theory, straight lines alone would indicate nothing fundamental in the fibers. Figure 6 is a comparison of a few of Steinberger's plots with the theoretical curves obtained. The points and solid lines are from Steinberger's paper; the dashed curves are theoretical. It is noted that in some cases Steinberger's straight lines agree quite well with theory; in others, it is clear that his choice of points through which he drew his lines was poor, and there is no reason why other straight lines which approach the theoretical curves could not have been chosen which would have passed through just as many experimental points.

In applying the theory to Steinberger's data, one must first choose the upper and lower limits of elongation. The lower limit, corresponding to the spring constant k' for the spring s' is fairly constant, and there is no theoretical basis which would indicate that this should change with relative humidity for a definite load, and thus if the fibers used for the various tests were identical, these initial elongations should be the same in all cases. It is seen that all of the experimental curves apparently originate at a percentage elongation from 1.5 to 1.75 percent, which is in fairly good agreement with theory.

A variation in the individual fibers is much more apparent in the total final elongation which is reached before the degradation of the fibers begins. Examination of the data shows that the total elongation values range from 11.75 to 22.0 percent. In the case of the runs at relative humidities of 0 to 60 percent the duration of the runs was not great enough to indicate the final elongation reached. In consequence, to fit the experimental data, a value toward which the fibers seemed to be approaching as a final limit was assumed; in this case the value

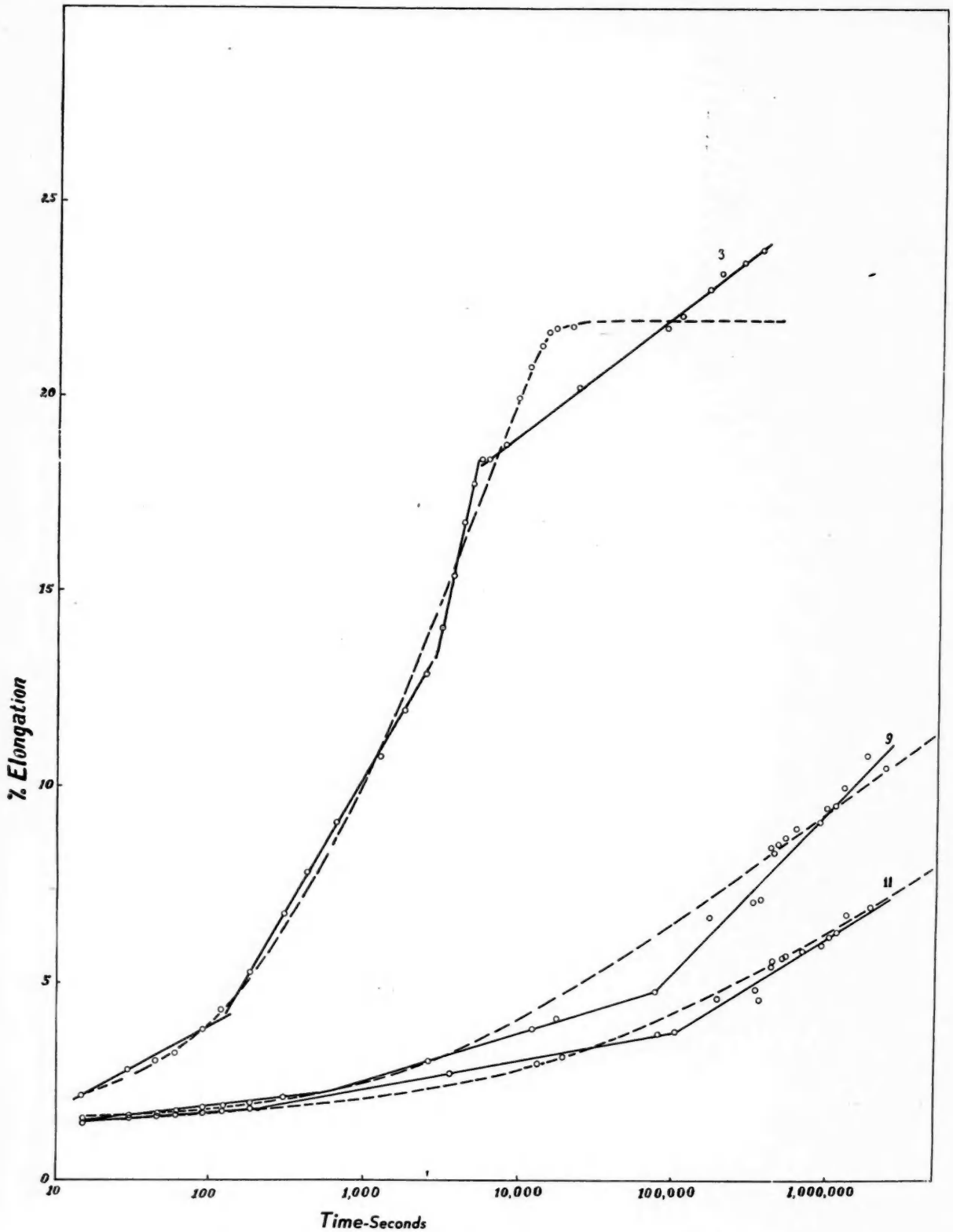

FIG. 6. *Comparison of Steinberger's curves with the theoretical.*

of 16 percent elongation was taken from examination of the character of the plots.

The effect of varying the value of the final elongation reached is apparent in the case of curve 5 of Figure 3, which is the Series 2 run at 71.0 percent relative humidity. Inspection of the points shows that two choices for the final elongation are possible. First, the curve appears to approach the value of 12.5 percent as an upper limit; however, a value of 16.0 percent elongation might also be chosen as the upper limit, attributing the deviations from the theoretical curve in the upper regions of the curve to irregularity or degradation of that particular fiber. The theoretical curve for a value of 12.5 percent final elongation is represented by the dashed line in Figure 3, and agreement of the curve with the points in the region of the curve is fairly good. The solid line for curve 5 of Figure 3 represents the theoretical curve for a value of 16 percent for the total elongation, and the points agree fairly well with the theoretical, except in the upper region of the curve. The theoretical constants obtained for those two values vary, as is shown in Table I. The two sets of values obtained may be considered to be within the total variation obtained when the relative humidity is changed; however, the dashed curve does not appear to represent the behavior of the fiber as well as the solid curve and therefore is discarded as non-representative.

V. Conclusions

Steinberger's data are not sufficiently complete for other than a qualitative study, as curves 1 to 5 in Figure 3, corresponding to relative humidities from 40 to 71.0 percent, are too erratic, undoubtedly because the runs were carried out too near the breaking point. The loads are fairly heavy for the fiber, and degradation of the fiber occurs rapidly, but they can be used to indicate the trend of the data and when compared with curves 6 to 15, corresponding to runs at relative humidities from 60 to 0 percent, respectively, they are quite revealing. It is noted that the spring constants k and k' remain practically constant; the dashpot constant K decreases with decreasing relative humidity values, showing that the dashpot becomes stiffer at lower relative humidities. At the same time the volume of the flow unit and the energy of activation are increasing with decreasing relative humidity. This is an indication that the properties of the cellulose acetate fibers change progressively from 0 to 60 percent, that there is a great change between 60 and 70 percent, and that from 70 percent upwards there is relatively little further change; however, the data are not complete enough definitely to establish this conclusion.

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Cellulose Studies
VI. Determination of Carboxyl Groups in Cellulosic Materials*

Lejaren Arthur Hiller, Jr.,† and Eugene Pacsu

Contribution from The Textile Foundation and the Frick Chemical Laboratory at Princeton University

IT has been known for a long time that cellulose has the property of being able to replace metallic ions of a salt solution with hydrogen ions. This phenomenon generally has been attributed to the existence of carboxyl groups in cellulose [1, 2]. Walker and Quell [3] arrived at the conclusion that these groups already exist in salt form, this opinion having been reached upon examination of cellulosic ash.

Many attempts have been made to obtain a quantitative estimation of these carboxyl groups. The majority of the methods which have been developed have depended on this type of reaction:

$$RCOOH + MA \rightarrow RCOOM + HA.$$

The problem of whether some or all of the acid groups already exist in salt form was handled by washing the cellulose sample first with strong acid, thus replacing the metallic ions with hydrogen ions.

Schwalbe and Becker [4] suggested direct titration of the cellulose with alkali in the presence of an indicator. They were able to distinguish between "oxycellulose" and unmodified cellulose in this manner, showing that the former possessed considerable carboxyl content.

Schmidt and his coworkers [5] also attempted direct titrations using both indicator and conductometric methods. Their procedures were criticized by Neale and Stringfellow [2] who could not obtain reproducible results. Using thymolphthalein as an indicator, the latter investigators observed drifts in the end-points, and the curves for the conductometric method showed no sharp inflection points which would correspond to a simple neutralization reaction.

One of the much used methods for carboxyl group estimation has been the absorption of certain dyes such as methylene blue by cellulose which contains acid groups. This procedure has been modified many times but it cannot be regarded as a quantitative determination, for the values obtained depend on the conditions under which the procedure is employed. For instance, the values depend greatly on the pH of the dye solution.

Lüdtke [6] suggested titration in an excess of calcium acetate solution. The carboxyl groups of the cellulosic materials were supposed to react as follows:

$$2RCOOH + CaAc_2 \rightarrow (RCOO)_2Ca + 2HAc.$$

Thus an equivalent quantity of acetic acid would be liberated which then could be titrated with dilute alkali. But under repeated investigations this method has been shown by Neale and Stringfellow [2] to be inaccurate. It has been explained that this inaccuracy is due to the buffering action of the system calcium acetate-acetic acid. Lüdtke's method was subsequently modified by Heymann and Rabinow [7, 8] and by Yackel and Kenyon [9]. The method is based on the assumption that acidic "oxycellulose" (and cellulose) is a stronger acid than acetic acid, which is probably true. However, even if the buffered system did not exist, there seems to be little justification in liberating a still weaker acid than the cellulosic materials for titration, for if the latter substances represent the stronger acids, they should titrate more readily than acetic acid.

Neale and Stringfellow [2] have employed a method of titration which involves the addition of an excess of dilute sodium hydroxide solution to a cellulose sample in the presence of sodium chloride, followed by back-titration with hydrochloric acid to a bromocresol purple end-point. Sodium chloride solution was used to give the hydrogen ions from the cellulose greater mobility in line with the Donnan membrane equilibrium theory. In tests on celluloses and "oxycelluloses" results were obtained which checked within a few percents. Changing the length of time that the sample stood in the excess of sodium

* This is the sixth paper in a series—"Cellulose Studies." The other five have appeared in the October, 1945, and the March, April, June, and July, 1946, issues.

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hydroxide solution apparently caused no change in the results. It was found that the acid values of certain "oxycelluloses" were proportional to the amount of oxidizing agent used in the preparation of the oxycellulose.

Sookne and Harris [1] recently developed a new method involving a replacement reaction using silver ortho-nitrophenolate. The amount of silver which reacts with a cellulose sample is measured by comparison with a blank, using the Volhard silver titration procedure. The method apparently gives satisfactory results.

In the previous paper of this series [10] we presented a method of measuring reducing end-groups, making use of acidic potassium permanganate solution, which we claimed would selectively oxidize the reducing groups to carboxyl groups. In order to check the results of this method we needed a simple procedure for titrating the carboxyl groups. In selecting a method for this purpose we desired a process that was rapid and accurate. The following points were considered.

1. After oxidation of the reducing groups the acid value obtained would have two components: the oxidized aldehyde groups and the original carboxyl content. Therefore, titration for the original carboxyl content would be necessary before the permanganate reaction, in order to obtain a good check on the results of the oxidation reaction.

2. Celluloses, "hydrocelluloses," and the products of these materials after titration with acidic potassium permanganate would have carboxyl groups involving the first carbon atom of the glucose constituent only—that is, similar to gluconic acid. Any "uronic acid" content of these materials presumably would be negligible as compared to the acidic type of oxidized celluloses. The chemical behavior of these two acids toward alkali might be quite different. We have reason to believe that the uronic acids apparently undergo secondary reactions in an alkaline medium. If the acid group determination is confined to material which is probably of pure "-onic acid" type, such as we had in our experiments, this problem should not arise and a titration with alkali should proceed according to the simple stoichiometric equation for neutralization of acids.

We adopted a procedure basically similar to that of Neale and Stringfellow, but somewhat simpler. We added an excess of 0.02*N* sodium hydroxide solution to our carefully prepared sample, allowed the mixture to stand for a few minutes, then back-titrated with 0.02*N* hydrochloric acid. With phenolphthalein as an indicator, a very sharp and persistent end-point was obtained. The use of sodium chloride was apparently unnecessary, for the reactions were rapid and the results reproducible. For samples containing reducing groups and carboxyl groups the excess of alkali was kept small so that reactions with the former groups would not occur. It was found that the water used for the experiments must be exactly neutral to phenolphthalein. Our distilled water was only slightly acidic, but enough so to cause considerable error if this problem was not disposed of first.

Experimental Procedure

The cellulosic samples were washed with cold dilute (1–2 percent) sulfuric acid to replace any metallic ions present. This washing was followed by a thorough one with distilled water (neutral to phenolphthalein) until the washings were also neutral.

A small volume (20 to 30 milliliters) of distilled water was introduced into each of several 250-milliliter glass stoppered flasks. One drop of phenolphthalein was added to each and the contents of the flasks were neutralized with dilute sodium hydroxide solution. The cellulose samples, usually 1 gram each, were then added, followed by 10 milliliters of 0.02*N* sodium hydroxide solution. The flasks were vigorously shaken by hand for 3 to 5 minutes and then each was back-titrated to the end-point with 0.02*N* sulfuric acid.

This procedure was applied to the following samples: (a) surgical cotton, (b) surgical cotton previously treated for 24 hours with 5*N* hydrochloric acid at 20°C—a "hydrocellulose."

The procedure employed was:

(1) Determination of original carboxyl content by the above method,
(2) Determination of reducing groups by acidic potassium permanganate solution which oxidizes the reducing groups to carboxyl groups, as described in Part V of this series [10], and
(3) Determination of total carboxyl content by the above procedure.

As a rule, 1-gram samples of the materials were weighed out and put through this procedure. The samples were very carefully washed after each determination, as described above. The results of a few typical determinations are summarized in Table I.

TABLE I. DETERMINATION OF CARBOXYL GROUPS IN 1-GRAM SAMPLES OF CELLULOSIC MATERIALS

		Cotton		Hydrocellulose	
	Sample No.	1	2	1	2
A. Initial carboxyl content	Volume alkali (milliliter)	10.01	10.05	10.05	10.11
0.0255*N* NaOH	Volume acid (milliliter)	11.20	11.27	11.19	11.29
0.0223*N* H_2SO_4	Milliequivalent alkali	0.255	0.256	0.256	0.257
	Milliequivalent acid	0.250	0.251	0.250	0.252
	Milliequivalent −COOH initial per gram	0.005	0.005	0.006	0.005
B. Aldehyde content	Volume $KMnO_4$ (milliliter)	7.60	7.71	7.63	7.80
0.0847*N* $KMnO_4$	Volume $Fe(NH_4)_2(SO_4)_2$ (milliliter)	7.64	7.74	7.90	8.08
0.0787*N* $Fe(NH_4)_2(SO_4)_2$	Milliequivalent $KMnO_4$	0.644	0.653	0.646	0.661
	Milliequivalent $Fe(NH_4)_2(SO_4)_2$	0.601	0.609	0.620	0.636
	Milliequivalent −CHO per gram	0.043	0.044	0.026	0.025
C. Total carboxyl content after $KMnO_4$ oxidation treatment	Volume alkali (milliliter)	10.30	10.45	10.27	10.30
0.0255*N* NaOH	Volume acid (milliliter)	10.56	10.84	10.95	11.08
0.0223*N* H_2SO_4	Milliequivalent alkali	0.263	0.268	0.262	0.263
	Milliequivalent acid	0.235	0.242	0.244	0.016
	Total −COOH per gram (milliequivalent)	0.028	0.026	0.018	0.016
	Milliequivalent −COOH total less milliequivalent −COOH initial	0.023	0.021	0.012	0.011

Both the cotton and "hydrocellulose" have a small original carboxyl content. It is of the order of magnitude of the results obtained by other procedures. When this value is subtracted from the total carboxyl content obtained after oxidation, the amount of sodium hydroxide consumed becomes almost one-half the amount of potassium permanganate used up in both cases. This is what it should be if the stoichiometric equation, $RCHO + O \rightarrow RCOOH$, is valid, as it apparently is.

Summary

A simple procedure for titrating carboxyl groups in cellulosic materials with dilute sodium hydroxide solution is presented. This involved adding an excess of sodium hydroxide, followed by back-titration with dilute sulfuric acid in the presence of phenolphthalein.

Some conditions under which this type of titration was previously used, such as employment of sodium chloride solution, were found to be unnecessary.

The method gave results of a reasonable order of magnitude for original carboxyl content of cellulose.

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Office of Technical Services

UNDER the U. S. Department of Commerce, the Office of Technical Services has been established. O. T. S. will assume the functions performed by the Office of the Publication Board. It will also include the Technical Industrial Intelligence Branch, the National Inventors Council, and the Production, Research and Development Division.

O. T. S. has commenced publication of a pamphlet entitled "Technical Services." The first issue has just appeared under date of July 17. This pamphlet will describe the new organization and the new services that will be offered.

The Office of the Publication Board has been publishing, since the first of the year, a weekly *Bibliography of Scientific and Industrial Reports.* This *Bibliography* is comprised of abstracts of reports of wartime research in America and enemy countries, and issued as rapidly as such reports can be catalogued and filed in Washington.

Since the appearance of this *Bibliography*, TEXTILE RESEARCH JOURNAL has reprinted the abstract references to textile reports as a service to its readers. In this issue, these will be found on page 407.

The weekly *Bibliography* is available on subscription. For information concerning both "Technical Services" and the *Bibliography* write to U. S. Department of Commerce, Office of Technical Services, Washington 25, D. C.

Book Reviews

Fluorochemistry: A Comprehensive Study Embracing the Theory and Application of Luminescence and Radiation in Physicochemical Science. Jack De Ment. Brooklyn, N. Y., Chemical Publishing Company, 1945. 796 pages. Price, $14.50.

(Reviewed by Henry Eyring)

The author tells us that "Fluorochemistry embraces the theory and applications of luminescence and radiation to chemical science." He states, as the first law for which he takes responsibility, that "before emission can occur from a luminescent system, absorption must first take place." As the author points out, the law is frequently violated; an example is chemiluminescence, where chemical energy is transformed into radiation. Actually, all that can be rigorously stated is that energy is conserved—that is, before emission can occur from a luminescent system, the emitted energy must have become available in some one of a wide variety of ways, one of which is by absorption of radiation. Similarly, his second law—that is, Stokes' law that emitted energy is of longer wave length than the absorbed radiation—is, as he concedes, frequently violated, notably in the Raman effect.

De Ment's third law of fluorescence is that "the absorption of radiation by a luminescent system is a quantum process involving one quantum per absorbing center; the yield of luminescence, then, in the ideal case being unity." The only objection here is that ideal cases are very scarce.

In the lengthy descriptive parts of the book there is gathered together a considerable amount of interesting material on luminescence in its various forms. The presentation is not so quantitative or so critical as is possible at the present time. The thirty drawings often are not well done.

The chapter headings reveal the scope of the book:

I. Physical Aspects of Luminescence.
II. Physicochemical Aspects of Luminescence.
III. The Luminescent Organic Substances.
IV. The Luminescent Dyestuffs and Coloring Matters.
V. The Phosphor Modality: Quasichemical Systems.
VI. The Synthetic, Crystalline, Inorganic Phosphors.
VII. The Synthetic Vitreous Phosphors—Glasses.
VIII. The Organic Phosphors and Luminescent Plastics.
IX. The Natural Phosphors—Luminescent Minerals.
X. Ultraviolet Emitting Substances.
XI. The Ultraviolet Emitting Inorganic Substances.
XII. The Ultraviolet Emitting Organic and Metal-Organic Substances.
XIII. Fluorescent Gamma and X-Radiation.
XIV. Fluorescent Infra-Red Radiation.
XV. Aspects of Fluorobiology, I.
XVI. Aspects of Fluorobiology, II.

Organization: A Formulation of Principle. Alvin Brown. Trenton, N. J., Hibbert Printing Company, 1945. 308 + viii pages. Price, $3.00.

(Reviewed by H. W. Whitcomb)

In this book Mr. Brown draws on his long experience with a number of well-known business executives and companies to write a very intelligent and practical treatise on the principles of organization. In a workman-like manner he discusses the principles of organization and then goes on to the nature and delegation of responsibility through various types of organization. Throughout the book he ties up the many principles stated with practical conditions, making the book of interest to business men as well as to students of business principles.

A particularly helpful feature is the summarizing of the principles developed and substantiated in each chapter at the conclusion of the chapter. All of the principles are then indexed at the end of the book, providing a ready reference to the foregoing material as well as a definite summary of the book's contents.

This book should be of interest to the average general executive as well as those particularly concerned with the organization and defining of responsibility in any large company.

Cotton Magic. Mildred Gwin Barnwell. Clinton, S. C., The Jacobs Press, 1945. 114 pages. Price, $2.00.

(*Reviewed by Robert B. Evans*)

This is an excellent nontechnical description of cotton-textile manufacturing, designed to be "readable material for the average person not interested in textile technology, and yet suitable material for a high-school industrial course." It is written in clear, simple style and should pay important dividends in good will to the industry if it reaches the persons for whom it is intended. It might even be suggested as good reading for industry executives and technologists on the theory that a brief, over-all glimpse of the forest enables one to see individual trees in better perspective.

Starting with an introductory chapter on the "Romance of Cotton," the author tells how cotton is classed, and then follows it through the mill from the opening room to finishing the fabric, with additional chapters on "Knitting," "Cotton Waste," and a final one on "Good Jobs and New Worlds." There are a brief glossary and a bibliography and the appendix includes schedules of cotton and cotton-waste prices, a table giving production of cotton in the United States from 1933 through 1942, and model layouts for combed-yarn and broadcloth mills.

Although the technical processes of the cotton mill are covered adequately, considering the book's purpose, one wonders if its value would not have been increased if there had been some discussion of certain other topics. For instance, nothing is said about how cotton fabrics are converted into usable consumer goods such as dresses, shirts, and bags, or regarding the relative importance of these and other end-products. Since the book is aimed at high-school students, some attention might well have been given to pointing out the opportunities for careers in the industry and the steps to take in preparing for such careers.

ABSTRACTS

SERVICES AVAILABLE

Reprints of the original articles abstracted in TEXTILE RESEARCH JOURNAL *are often available from the publishers. Otherwise, it may be possible to secure copies of the periodicals. Orders should be sent direct to the publishers.*

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A list of periodicals, the abbreviations used in references to articles, and the addresses of publishers of English language publications is given on page 84 of the February, 1946, issue.

ANALYSIS: TESTING: LABORATORY METHODS

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Antiseptic Fabrics

A suggested method for thorough testing of antiseptic fabrics. Louis C. Barail. *A. S. T. M. Bull.* No. **136**, 25–31 (Oct. 1945).

The tests are divided into two categories: informative tests such as toxicity, effect on skin, and phenol coefficient; and performance tests such as sterility, bacteriostasis against selected bacteria, and fungicidal value. A. R. Martin

Text. Research J. Aug. 1946

Fatigue Tests

Comparative fatigue test data. C. S. Venable. *A. S. T. M. Bull.* No. **136**, 17–19 (Oct. 1945).

Data are given on 14 rayon tire yarns manufactured under different conditions and tested by 14 different test machines. In general, the agreement is good, suggesting some "common denominator" for all these fatigue tests. It is suggested that yarn "toughness" is more important than tensile strength and is the fundamental factor involved. While the various tests can distinguish between good and bad samples, none has satisfactory sensitivity to small differences in quality to be adopted as a standard. A. R. Martin

Text. Research J. Aug. 1946

Statistical comparison of rayon tire cord fatigue testing machines. *A. S. T. M. Bull.* No. **136**, 19–25 (Oct. 1945).

A statistical analysis of Venable's data (*cf.* previous abstract). It is concluded that, although correlations are found that might be satisfactory in some economic or biological surveys, the accuracy of predicting fatigue results from strength and elongation data leaves much to be desired. There remain unknown elements shared by each of the test machines. A. R. Martin

Text. Research J. Aug. 1946

Moisture Determination

Titrimetric procedures using Karl Fischer reagent. G. Wernimont. *Synthetic Org. Chemicals* **18**, No. 1, 3 pp. (1946).

Karl Fischer method for determining moisture in inorganic and organic liquids and solids is discussed. The method is applicable on a macro and micro scale. 12 references. W. Raczynski

Text. Research J. Aug. 1946

Molecular Weight Determination by Optical Methods

A light-scattering investigation of cellulose acetate. R. S. Stein and Paul Doty. *J. Am. Chem. Soc.* **68**, 159–67 (Feb. 1946); *cf.* TEXTILE RESEARCH JOURNAL **16**, 96 (Feb. 1946).

A discussion is given of the complications in the light-scattering method of molecular-weight determination when the molecules are large enough to give a dissymmetrical angular intensity distribution. An instrument for the absolute measurement of turbidity is described together with the method of calibration. An instrument for the measurement of the angular distribution of intensity of scattered light is described. Measurements of turbidity, dissymmetry, refractive index increment, and depolarization were made on solutions of 4 cellulose-acetate fractions whose molecular weights had been otherwise determined. The molecular weights calculated from the optical measurements agreed within 8% of those measured by other means. The empirical constant, μ, which characterizes the deviation from van't Hoff's law was found to be 0.45 ± 0.01 by light-scattering measurements as compared with 0.43 ± 0.005 based on osmotic-pressure measurements for the cellulose acetate-acetone system. The angular variation of intensity is found to be in agreement with the theoretical prediction. The comparison of the measured dissymmetry with that predicted theoretically for a rod-shaped or random coil molecule indicates that the cellulose acetate molecule in acetone solution is

rather extended up to a molecular weight of about 80,000. At higher molecular weights the molecule may coil back on itself to a degree that increases rapidly with molecular weight. Authors

Text. Research J. Aug. 1946

Reactions of Oxycellulose

Critical studies of cellulose reactions. R. Haller. *Schweiz. Arch. angew. Wiss. Tech.* **11**, 145–7 (1945) (through *Chem. Abstr.* **40**, 2981[6] (May 20, 1946)).

There are only 3 reliable methods of differentiating between oxycellulose (*I*) and hydrocellulose (*II*): (1) the Sn–Au reaction, depending on the affinity of metallic oxides for a certain *I* component, which forms Cassius gold purple; (2) the $FeCl_3$ reaction, in which *I* yields a blue color, whereas *II* gives a negative reaction; (3) Müller's nitrophenylhydrazine method, which allows the determination of *I* and *II* by osazone formation. Haller concludes that *I* contains a component which reacts with metallic oxides and that *II* lacks this component. The composition of *I* may be found by isolating this metallic oxide compound and identifying its organic constituent.

Text. Research J. Aug. 1946

Adhesion of Rubber to Cord

The single-cord compression adhesion test for evaluating the adhesion of vulcanized rubber to cord. E. T. Lessig and J. Compton. *Rubber Chem. Tech.* **19**, 223–32 (Jan. 1946).

The preparation of cylindrical rubber test pieces in which the embedded cord lies at right angles to the axis of the cylinder is described, with the variations necessary when testing untreated, dipped, or calendered cord. Descriptions and photographs of the required apparatus are given. The adhesion test consists in measuring the pressure which must be applied to the ends of the cylindrical test piece to cause separation of the rubber from the cord. The interpretation of the results depends on the type of failure which occurs; the test piece is cut open for the determination. Data are presented to show reproducibility and to illustrate the effect of temperature on adhesion. The effect of cord material (cotton or rayon) and construction on adhesion is discussed. W. E. Davis

Text. Research J. Aug. 1946

Rubber Testing

Comparison of methods for examining the scorching of rubber stocks. J. F. Morley, J. R. Scott, and W. H. Willott. *Rubber Chem. Tech.* **18**, 460–70 (Apr. 1945).

Three methods of determining scorching were examined; one, involving the gelation time on heating of a solution of the stock, was unsuccessful. The others (determination of plasticity and measurement of solubility in benzene) gave approximately equivalent results. The plasticity method has been widely used, but the solubility method is much simpler, though not universally applicable, as unscorched stocks which contain considerable percentages of strongly reinforcing fillers are not soluble in benzene. The plasticity method is more sensitive. W. E. Davis

Text. Research J. Aug. 1946

Tire Fatigue Machine

An automotive tire fatigue machine. John N. Kenyon. *A. S. T. M. Bull.* No. **136**, 9–12 (Oct. 1945).

A tire fatigue machine is described and data obtained which indicate that the speeding pneumatic tire is subjected to the greatest dynamical stress at the top or 180° from the point of contact with the roadbed. Theory is advanced that a "standing" sinusoidal-type wave builds up in the perimeter of the speeding tire and attains its maximum surge at the top or undampened part of the tire structure. Simultaneously a complementary wave system is set up in the sidewalls, which results in an ultimate cracking up, "oxidation fatigue," of the protective rubber covering. Author

Text. Research J. Aug. 1946

Tropical Testing Chamber

Tropical testing chamber. T. F. Cooke and R. E. Vicklund. *Ind. Eng. Chem., Anal. Ed.* **18**, 89–90 (Jan. 1946).

The construction of the 14x32x12-ft. tropical testing chamber used by the U. S. Army Engineer Board at Fort Belvoir is described. A temperature-and-humidity cycle of 18 hrs. at 85°F ± 1°F and a relative humidity of 90 ± 2%, followed by 6 hrs. at 75°F ± 1°F and a relative humidity of 95 ± 2%, is maintained in the chamber. Spore-suspensions of 24 species of fungi, mainly tropical, were introduced into the chamber. Other fungi are undoubtedly present. Soil-burial pans are kept in the chamber. The chamber has been used for testing many Army items, including optical instruments and textile items. A. R. Macormac

Text. Research J. Aug. 1946

Viscometry

Rapid method for determining cuprammonium viscosity. Committee on Analysis, Cellulosaindustriens Centrallaboratoriums. *Svensk Papperstidn.* **49**, 148–53 (Apr. 15, 1946); summary in German, 154–5; in English, 155–6.

Accepted in 1944 as CCA 16, this method is an improvement over CCA 13, which in turn was essentially the TAPPI method. Time is saved by pretreating the sample with ammonia to accelerate solution of cellulose. Dissolving time is thus shortened from about 15 hrs. to 10 min. or less. The method is recommended especially for pulps with viscosity below 40 centipoises. For high-viscosity pulps there may be some degradation of the cellulose in this method. J. F. S.

Text. Research J. Aug. 1946

Viscose

Factors influencing filtration of viscose. Risto Vuori, A. B. Centrallaboratorium. *Svensk Papperstidn.* **49**, 95–6 (Mar. 15, 1946).

Tests with NaCl 1.15, CaO 0.1, Na_2SiO_3 5.5, Na_2CO_3 3.0, tall oil resin 0.5, hemicellulose up to 1.9, and mixed sea-water salts 0.046% indicated that these extraneous additions to the mercerizing lye in making viscose have no significant effect on the filtering properties of viscose.

Apparently the principal factor in filtration behavior is the uniformity of degree of polymerization (D.P.). Clogging of filters appears to be caused by unusually long molecular chains; for example, the average D.P. of the viscose in a factory operation was 248, whereas the average of the slime removed from clogged filters was 554. Further study is needed to ascertain whether the influence is exerted directly or indirectly. J. F. S.

Text. Research J. Aug. 1946

CHEMICAL AND PHYSICAL RESEARCH

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Catalytic Oxidation of Cellulose

The oxidation of cellulose by sodium hypochlorite in presence of ferrous hydroxide. G. M. Nabar and H. A. Turner. *J. Soc. Dyers and Colourists* **61**, 258–63 (Oct. 1945).

The presence of ferrous hydroxide, deposited upon the fiber, causes a very marked acceleration of the oxidation of cotton cellulose by dilute sodium hypochlorite solutions. The magnitude of the acceleration is of the same order as that produced by the reduced form of the most active vat dyes. Ferric hydroxide, applied under similar conditions, has practically no activity. The rise in cuprammonium fluidity and in copper number brought about by the accelerated oxidation is in approximately linear relationship to the oxygen consumed, except for experiments in which the oxygen consumption is very low. The variation of these properties with oxygen consumption is not the same as that for leuco-vat-dye accelerated oxidation; under similar experimental conditions, the ferrous hydroxide appears to cause the transfer of more oxygen from the hypochlorite to a given weight of cellulose than does the most active dye yet examined. Authors

Text. Research J. Aug. 1946

Cellulose-Acetate Hydrolysis

Heterogeneous acid and acid-salt hydrolysis of secondary cellulose acetate. R. N. Howard and T. White. *J. Soc. Chem. Ind.* **65**, 63–4 (Feb. 1946).

The heterogeneous hydrolysis of secondary cellulose acetate has been investigated in aqueous solutions of acids and acid-salt mixtures. A marked anionic effect occurs with neutral salts increasing the rate of reaction, but the lyotropic series is arranged in opposite order to that reported elsewhere in the case of homogeneous hydrolysis. Authors

Text. Research J. Aug. 1946

Iron Compounds as Oxidation Catalysts

The influence of compounds of iron upon oxidation reactions. H. A. Turner. *J. Soc. Dyers and Colourists* **61**, 255–8 (Oct. 1945).

A review of the information available dealing with the catalytic effect of iron compounds during oxidation reactions. The significance of certain of this material in connection with bleaching and other textile processes is noted. K. S. Campbell

Text. Research J. Aug. 1946

Elastic Properties of Cork

Elastic properties of cork. I. Stress relaxation of compressed cork. S. L. Dart and Eugene Guth. *J. Applied Phys.* **17**, 314–18 (May 1946).

Data are presented on the stress relaxation of natural cork at various degrees of compression and at temperatures ranging from 30 to 200°C. An automatic stress-relaxation apparatus based upon the chainomatic principle is described. Cork exhibits a typical sigmoid type of stress-strain curve. When relaxation of stress under constant deformation is plotted against log t, where t is the time during which the specimen is under compression, a linear relationship is obtained. The dependency of stress relaxation upon deformation, time, and temperature is discussed. T. J. Dietz

Text. Research J. Aug. 1946

Flow Properties of Dispersions

Theory of the rheological properties of dispersions. H. Fröhlich and R. Sack. *Proc. Roy. Soc.* **A185**, 415–30 (Apr. 5, 1946).

A theory of flow of substances showing elastic recovery is developed. It leads to a set of differential equations which contain three parameters. In the case of dispersions these parameters can be derived from the properties and the composition of the components.

Text. Research J. Aug. 1946 Authors

Viscous Flow

The molecular mechanism of viscous flow. T. Alfrey. *Rheol. Bull.* **16**, 3–8 (1945) (through *Chem. Abstr.* **40**, 2706[3] (May 20, 1946)).

The specific model used by Eyring and his coworkers (cf. *C.A.* **32**, 15[1])* in their theory of viscous flow has been questioned on certain minor geometrical grounds, particularly with respect to the effect of stress and strain fields and to producing a velocity gradient. This paper attempts to clarify these geometrical aspects of the problem.

Text. Research J. Aug. 1946

Diffusion of Gases Through Polymers

On the diffusion of vapors through polymers. Paul Doty. *J. Chem. Phys.* **14**, 244–51 (Apr. 1946).

The rate of permeation of a gas through a polymer as a function of temperature may be represented as $P = P_o e^{-E/RT}$. All available data on the permeability of gases through polymers show that for a given gas there is a linear relationship between log P_o and E (the energy of activation for permeation). An explanation is offered for this apparent relationship. The effect of plasticization on permeation of water vapor is studied experimentally and it is shown that the lowering of the heat of solution is the predominant effect. From the data the entropy of solution may be calculated and

* Hirschfelder, Stevenson, and Eyring, *J. Chem. Phys.* **5**, 896–12 (1937).

interpreted as showing that water molecules dissolved in the unplasticized polymer exhibit much less freedom than when they are dissolved in plasticized polymer. Other calculations show (in agreement with Barrer) that a large number of degrees of freedom are simultaneously operative in the process of the diffusion of a gas molecule through a polymer. Author
Text. Research J. Aug. 1946

Molecular Weight of High Polymers

Recent advances in the physics and chemistry of rubber. I. The size and shape of the rubber molecule. G. Gee. *Rubber Chem. Tech.* **18**, 707–11 (Oct. 1945).

A discussion of various methods for determining the molecular weight of high polymers, such as osmotic pressure, freezing-point depression, boiling-point elevation, ultracentrifuge, and viscosity. The effect of molecular size and shape on intrinsic viscosity is discussed briefly.
Text. Research J. Aug. 1946 W. E. Davis

Dissociation Constants of Polysaccharides

The dissociation constants of the carboxyl and hydroxyl groups in some insoluble and sol-forming polysaccharides. S. P. Saric and R. K. Schofield. *Proc. Roy. Soc.* **A185**, 431–47 (Apr. 5, 1946).

A method is described for determining dissociation constants by electrometric titration of a substance suspended or dissolved in a salt solution. Most of the materials tested, whether soluble or not, followed the simple Henderson equation for dissociation of a weak acid or base in true solution, and all gave the same value of pH for carboxyl dissociation, namely, 2.95. Since both uronic and gluconic carboxyl groups were present in various samples, it appears that these two types of acid have about the same dissociation constant. Departure of pectic acid from the Henderson curve is attributed to hydrogen-bridge formation between neighboring carboxyl groups. Gel formation by alginic acid below pH 3 is also attributed to hydrogen bridges. By extending the measurements to the high pH range, dissociation constants for hydroxyl groups were also measured for some of the materials.
Text. Research J. Aug. 1946 W. E. Davis

Donnan Equilibria in Protein Systems

Donnan equilibria and molecular effects in protein systems. The permanent disorganization and changed reactivity of collagen pretreated in acid solutions. K. H. Gustavson. *Svensk Kem. Tid.* **55**, 191–200 (1943) (in English); cf. *C.A.* **35**, 1422[7]; **36**, 291[5] (through *Chem. Abstr.* **40**, 2860[1] (May 20, 1946)).

Contrary to the usual Donnan equilibria theory, the properties and reactivity of collagen are permanently changed to different extents when treated with various acid solutions. Pretreatment with AcOH results in a large permanent swelling, whereas HCl shows only a slight permanent swelling. This suggests the specific effects of both molecules and ions, and supports the view that tanning agents react by means of both coordinate and ionic valency forces, after the cross-linkages of the polypeptide chains are activated by rupture or disorganization.
Text. Research J. Aug. 1946

Crystallinity of Rubber

Recent advances in the physics and chemistry of rubber. IV. Crystallization in rubbers. L. R. G. Treloar. *Rubber Chem. Tech.* **18**, 724–30 (Oct. 1945).

Crystallization and "melting" phenomena in rubber are compared and contrasted with those in simple liquids. Data on the rate and extent of crystallization produced by stretching rubber are presented, using methods based on changes in density and birefringence, and the effect of vulcanization on rate of crystallization is discussed. X-ray methods of studying crystallization are described and results for rubber are given. The effects of crystallization on the mechanical properties of rubber are discussed briefly.
Text. Research J. Aug. 1946 W. E. Davis

Synthetic Rubber

Molecular requirements for synthetic rubbers. W. O. Baker. *Rubber Chem. Tech.* **18**, 632–6 (July 1945).

A discussion of the effect on rubberlike elasticity of chain flexibility, interchain attractive forces, and nonpolar side groups, with illustrative experimental data on "model molecules" of polypropylene sebacate, polyethylene sebacate, and polyethylene. The low strength of GR-S as compared with natural rubber is attributed to irregular distribution of phenyl groups in GR-S, leading to interchain attractive forces which are too small.
Text. Research J. Aug. 1946 W. E. Davis

Theory of Swelling of Rubber by Liquids

Recent advances in the physics and chemistry of rubber. III. The solubility and swelling of rubbers. G. Gee. *Rubber Chem. Tech.* **18**, 716–23 (Oct. 1945).

A semiquantitative account of the solvent and swelling action of single and mixed liquids on raw and vulcanized, natural and synthetic rubbers, based on relationships among the cohesive energy densities of the various components of a given system. More nearly quantitative explanation is possible at the expense of generality, but even the simplified picture presented here is surprisingly successful in accounting for some of the phenomena of swelling in mixed solvents which at first sight appear anomalous. W. E. Davis
Text. Research J. Aug. 1946

Chemical Structure and Rubberlike Elasticity

Recent advances in the physics and chemistry of rubber. II. The kinetic theory of rubber elasticity. L. R. G. Treloar. *Rubber Chem. Tech.* **18**, 712–15 (Oct. 1945).

The rubber molecule tends to assume a randomly kinked configuration because of thermal motion, which is important in the recovery of rubber after extension. The following conditions for occurrence of rubberlike elasticity are pre-

sented: (1) the presence of long-chain molecules, with freely-rotating links; (2) weak secondary forces around these molecules; and (3) a few points of cross-linkage, resulting in a loose, three-dimensional network. The fulfillment of these conditions in actual rubbers is discussed briefly. W. E. Davis

Text. Research J. Aug. 1946

Organic Silicon Compounds

Silicon organics. Harold Hausman. *J. Chem. Ed.* **23**, 16–21 (Jan. 1946).

A review is given of the chemistry of organic silicon compounds, with emphasis on their polymers and some of their applications. 41 references. R. K. Worner

Text. Research J. Aug. 1946

Dipolar Solids

Dielectric properties of dipolar solids. H. Fröhlich. *Proc. Roy. Soc.* **A185**, 399–414 (Apr. 5, 1946).

A quantitative theory of the dielectric properties of crystalline solids consisting of dipolar long-chain molecules is developed (one dipole per mol.). In these solids the dipoles are concentrated in dipolar planes. In the ground state the dipolar planes have a permanent polarization, but usually the polarizations of successive planes have opposite directions. The static dielectric constant rises with increasing temperature up to a critical temperature T_0 and then decreases. At T_0 the substance has a phase transition of the second kind. Comparison with experiments by Müller on a solid ketone leads to good agreement. For chains with an even number of C atoms, metastable states with a permanent polarization are predicted, and a method to reach these states is discussed. The interaction between dipoles plays a predominant role at temperatures below T_0. It is shown that both Lorentz' and Onsager's methods are invalid in this temperature range.

Text. Research J. Aug. 1946 Author

Solutions of Large Molecules

Application of the methods of molecular distribution to solutions of large molecules. Bruno H. Zimm. *J. Chem. Phys.* **14**, 164–79 (Mar. 1946).

The equations for the thermodynamic potentials of the solvent in solutions of ordinary organic molecules are extended to solutions of large molecules by methods using continuous molecular distribution functions. Particular attention is given to the coefficient, A_2, of the second term in the expansion of the osmotic pressure in terms of the concentration, since this coefficient has a simple molecular meaning and is sufficient to describe the deviation of the system from ideality at low concentrations. A_2 is calculated by direct integration for two rigid shapes, the sphere and the long thin rod. A general expression is then developed for A_2 for flexible chain molecules in terms of the interactions of the segments of the chains. In favorable cases it is found possible to relate A_2 for a chain molecule to the solution properties of its small molecule homologs by an equation very similar to those developed by Flory, Huggins, and Miller. In general, however, interactions that depend both on the local structure and also on the overall shape of the chain molecules seriously modify such a relationship. The nature of these interactions, including the effects of branching and of limited flexibility, is discussed. It is also shown that higher coefficients in the expansion of the osmotic pressure in terms of concentration can be treated in a similar way. Comparison with experimental data confirms the general predictions of the theory both for proteins and chain polymers. Author

Text. Research J. Aug. 1946

Sulfated Oils

Manufacture, blends, and uses of sulfated oils. I. Blends with mineral oil. S. Glicher. *Petroleum* (London) **8**, No. 2, 32, 35 (1945) (through *Chem. Abstr.* **40**, 3283[1] (June 10, 1946)).

The chemical constitution of the various raw materials is briefly discussed. Sulfation is effected by H_2SO_4 under conditions such that sulfuric esters having an O bridge between S and C are produced. A brief description is given of the manufacturing conditions for the sulfation of castor oil, cod oil, neatsfoot oil, sperm oil, oleic acid, and fatty alcohols. **II.** *Ibid.* No. 4, 66. The production and properties of cutting oils, tannery fat-liquors, and disinfectants are briefly discussed. **III. Blended oils.** *Ibid.* No. 5, 95–6. The production and properties of fat-liquoring oils are discussed in some detail. Commercial blending to produce cheaper oils is reviewed. Sulfated fatty alcohols, esters, acid amides, aromatic compounds, and quaternary NH_4 compounds are reviewed as textile assistants.

Text. Research J. Aug. 1946

Properties of Tire Cords

The general relations for flow in solids and their application to the plastic behavior of tire cords. W. James Lyons. *J. Applied Phys.* **17**, 472–82 (June 1946).

Numerous researches on metals, rocks, glass, rubber, and textiles are cited to show that what may be regarded as normal creep in amorphous and polycrystalline solids conforms to the general relation

$$\epsilon = \epsilon_1 + at + b \log t,$$

where ϵ is the total strain at time t, ϵ_1 is a parameter interpretable as the approximate initial strain, and a, b are other parameters. A special form of this equation, having $a = 0$, has been frequently applied. Reference is made to several other studies on the same class of solids, which have established for normal relaxation the relation

$$\sigma = \sigma_1 - \beta \log t,$$

where σ is the stress at time t, σ_1 is the stress at unit time, and β is a parameter. A theoretical foundation for both equations is provided by the reaction-rate theory of plastic flow. Observations in the present study indicate that creep extension in cotton and rayon tire cords over prolonged periods of time follows the above creep equation, and, in

general, is not adequately represented by an equation omitting the term *at*. From the presence of this term in the equation, the existence of a component of the viscous type in tire cord growth is deduced. The pattern of creep recovery in cotton tire cord appears to be set by the behavior of the cord in creep extension. Author

Text. Research J. Aug. 1946

Efficiency of Wetting Agents

Efficiency of wetting agents. T. Krishnappa, K. S. Gururaja Doss, and Basrur Sanjiva Rao. *Proc. Indian Acad. Sci.* **23A**, No. 1, 1–7 (1946) (through *Chem. Abstr.* **40**, 3282[5] (June 10, 1946)).

Surface tension (γ) measurements at pH 3.7 with the maximum-bubble-pressure (I) and ring methods were used in evaluation of wetting agents; justification for this had been shown previously (*C.A.* **36**, 2461[9]). I was found unsuitable for measurement of γ of solutions showing a variation with time. Solutions having γ values less than 37 dynes per cm. were considered good wetting substances. By this standard Surfax, Igepon T, Gardinol C.A., and Ultrawon WX are very efficient. Nekal BX is less so and Diazopon A, Silvatol I, and Turkey Red Oil are inefficient. Bivalent ions are more effective than the univalent in increasing the wetting power of Nekal BX.

Text. Research J. Aug. 1946

BLEACHING: DYEING: FINISHING

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Dyeing Acetate, Nylon, and Vinyon

Textile fibers which swell slightly in water: mechanism of their dyeing and resulting possibilities. J. Corbière. *Chimie & Industrie* **50**, 94–100 (1943) (through *Chem. Abstr.* **40**, 3267[8] (June 10, 1946)).

By comparison of the degree of swelling in water with the essential properties of the various fibers (more particularly their dry and wet tensile strength), they can be divided into 2 classes: (1) strongly swelling fibers, unaffected by organic solvents, and capable of creping; (2) slightly swelling fibers (cellulose acetate, nylon, vinyl yarns), sensitive to certain organic solvents, and incapable of creping in aqueous medium. The mechanism of the drying of class (2) fibers is discussed. They have in common the property of themselves behaving as organic solvents and extracting from aqueous dispersions insoluble dyes and compounds. Their dyeing and related treatments (printing, removal, etc.) involve solid solution phenomena: the most suitable dyes and products are those which are fast on the spun materials. Dyes which have been found suitable for cellulose acetate are also suitable for nylon and vinyl chloride-acetate copolymers; but further investigation is necessary aiming at increasing the number of these dyes, lowering their cost, improving their dispersion, and their solubility in the fibers.

Text. Research J. Aug. 1946

Continuous Pigment-Pad Vat Dyeing

Continuous pigment-pad vat dyeing. Glenn F. Womble. *Rayon Text. Mo.* **27**, 316–18 (June 1946).

The fabric is impregnated on a padder with dispersed vat pigment, dried or semidried, then entered in an aqueous medium maintained usually at 160–210°F and containing alkali and reducing agents rapidly to affix the pigment *in situ* to the fabric. The intermediate drying step is necessary to prevent bleeding-off and subsequent re-deposition of color, giving a surface-dyed effect. For best results, the most careful control of every factor is required. In addition to various automatic controls, periodic titration of the reduction bath is recommended. Dyes must be used that reduce and dissolve in the minimum time.

Text. Research J. Aug. 1946 A. R. Martin

Cotton Printing

Printing properties of print-cotton dyes. M. G. Shikher. *J. Applied Chem.* (U.S.S.R.) **18**, 329–41 (1945) (English summary) (through *Chem. Abstr.* **40**, 3267[4] (June 10, 1946)).

The print dyes must have certain optimal resistance to deformative forces and the physical systems comprising the dye must be fine-structured. Thickeners such as Na alginate and colophony give solutions with less structure than obtained with starch; the alginate has the highest thickening power. Starch gives the least stickiness, but this rises rapidly as the hydrolysis of starch proceeds. All types of thickeners have a pronounced relationship of resistance to capillary forces vs. concentration; Na alginate and tragacanth gum have the most pronounced capacity in this respect; the latter, however, loses this power on "boiling."

Text. Research J. Aug. 1946

Substitute for Gum Tragacanth

Gum *Sterculia urens* as a thickener in textile printing. V. C. Patwardhan and S. R. Ramachandran. *J. Indian Chem. Soc., Ind. & News Ed.* **8**, 14–17 (1945) (through *Chem. Abstr.* **40**, 3608[3] (June 20, 1946)).

Indian gum or hog tragacanth can be used as a substitute for gum tragacanth in dye-printing pastes if it is first treated with Na_2O_2 as described in B. P. 120,183. One lb. of gum is added in small portions to 2.5 lbs. H_2O and 2 g. Na_2O_2 are added. The mixture is stirred for 1.5 hrs. at 30°, 2 g. Na_2O_2, and 100 ml. H_2O are added, and the whole is boiled for 3 hrs. The mucilage is cooled and diluted with H_2O to 1 gal.

Text. Research J. Aug. 1946

Vinyl-Coated Textiles

The use of vinyl resins in coatings of textiles. Eugène Simon. *Plastiques* **2**, 4–10 (1944) (through *Chem. Abstr.* **40**, 3622[3] (June 20, 1946)).

The war shortage of rubber and linseed oil in France brought about the use of vinyl resins for coatings which can be made from solvent cements, aqueous emulsions, and by

means of calenders. The properties of various plasticizers, fillers, dyes, and solvents for polyvinyl acetate-chloride and acetals, machinery (spreaders, mixers, calenders), and the specifications of the final product are described.

Text. Research J. Aug. 1946

Two-Color Effects on Wool

Colored effects on wool by new methods. Edgar I. Noble. *Text. J. Australia* **20**, 433–4 (1945) (through *Chem. Abstr.* **40**, 3267[3] (June 10, 1946)).

Various methods of producing tone-in-tone and two-colored effects in one dyeing operation are discussed; two methods are considered commercially satisfactory. Wool boiled with HCHO and "R" salt and H_2SO_4 and then baked resists dyeing with piece-dyeing colors sufficiently for the production of tone-in-tone effects; the process is cheap enough to represent advantages in comparison with ordinary methods. By mixing chlorinated and normal wools, tone-in-tone and two-colored effects or plain colors may be produced cheaply from one dye bath by choosing certain dyes and the use of Thiotan RS.

Text. Research J. Aug. 1946

FIBERS: YARNS: FABRICS: MECHANICAL PROCESSES

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Properties of Italian Broom Fiber

Structure and technological properties of the fibers of Italian broom. K. Wuhrmann. *Schweiz. Arch. angew. Wiss. Tech.* **11**, 138–44 (1945) (through *Chem. Abstr.* **40**, 2631[6] (May 10, 1946)).

Fibers, fabrics, and yarns of *Spartium junceum* L. are highly resistant to severe treatment with concentrated NaOH at high temperatures. The tear-resistance of the yarn after 20 hours' treatment with 15% NaOH at 85° and 110°, respectively, decreases only 2 and 9%. Broom fibers are therefore suitable for the manufacture of filter cloth for hot, concentrated alkaline solutions. The high alkali-resistance is due to the fact that the cells of the fiber are enclosed by a highly developed and incrusted primary wall, which has the structure of a flat left-handed screw. This prevents the introduction of the concentrated liquor into the interior of the fiber bundle; the swelling anisotropy of both membrane layers exerts itself in opposite directions and thus prevents the free reaction between fiber cellulose and alkali. The x-ray examination after various alkaline treatments showed also that broom fibers are transformed into hydrated cellulose only very slowly; hemp fibers are completely mercerized very readily. Hemp fibers are penetrated much more readily by alkalies than broom fibers.

Text. Research J. Aug. 1946

Peat Fibers

Some special applications of peat. (A) Peat for litters, for fertilizers, for packing fruits and vegetables. Ch. Berthelot. *Chimie & industrie* **49**, 75–8 (1943) (through *Chem. Abstr.* **40**, 2958[4] (May 20, 1946)).

A description of the characteristics of sphagnum peat and its preparation for use as litter for animals, fertilizer or soil improver, and packing fruits and vegetables. **(B) Textile fibers from peat.** *Ibid.*, 78–9. A description of the separation, washing, bleaching, and carding (Szchorner card) of peat fibers, of their characteristics, and of the uses of peat fabrics.

Text. Research J. Aug. 1946

Regenerated Protein Fibers

Progress of research on synthetic protein fibers. H. P. Lundgren. *Chemurgic Digest* **5**, 113 (Mar. 31, 1946).

Technical egg-white and feather protein have been extruded to produce true fibers having strengths as good as or better than casein fibers being produced commercially. New and improved fibers with controlled properties may be produced for specific applications.

W. Raczynski

Text. Research J. Aug. 1946

Fiber Glass

Fiber glass—its manufacture and uses. A. M. Robertson. *Chemistry and Industry* **No. 13**, 138–9 (Mar. 30, 1946); **No. 14**, 146–7 (Apr. 6, 1946).

The manufacture of glass fiber and the winding and weaving of the fiber are described. Glass cloth is used in filtration, electrical insulation, heat- and sound-insulation in air filters, and as packing for chemical equipment. W. Raczynski

Text. Research J. Aug. 1946

Electrocoated Fabrics

Electrocoated pile fabrics. Anon. *Chemurgic Digest* **5**, 106–7 (Mar. 15, 1946).

Description of the process of Behr-Manning Corporation for preparing pile fabrics by means of electrostatic coating. Cotton, wool, rayon, or other fibers are attached to adhesive-coated backing material. Dotted-swiss and embroidery effects are obtained by use of suitable stencils for applying the adhesive. The backing material may be cloth, paper, cellophane, plastic, etc. Densities of 300,000 fibers per in. are obtainable. W. Raczynski

Text. Research J. Aug. 1946

Coated Yarns

Plexon-plastic coated yarn. Anon. *Chemurgic Digest* **5**, 42–3 (Jan. 15, 1946).

Report on cotton, rayon, fiber glass, and silk yarns coated by extrusion with different plastic formulations including cellulose acetate or soybean protein. Material can be processed on existing types of weaving or knitting equipment.

W. Raczynski

Text. Research J. Aug. 1946

Worsted Carding

Fibre-breakage in worsted carding. P. P. Townend and E. Spiegel.

J. Text. Inst. **37**, T58–76 (Mar. 1946).

The purposes of this investigation were to determine the factors responsible for the breakage of fibers in worsted carding and to define the best conditions for minimizing these defects. The experiments, which were carried out mainly on 64s Australian Merino wool, may be classified under two headings—viz., those concerned with the state of the wool fed to the card and those concerned with mechanical alterations to the machine. Concerning the former experiments, it was found that less breakage occurs when wool is carded at regains greater than 20%. This is probably due to the fact that the fibers are more extensible at high than at low regains, so there is less chance of their being broken as they are disentangled by the wires during the carding process. Additions of grease and soap, while having no detrimental effect on fiber-breakage, do not materially assist in the prevention of breakage and, in any case, are undesirable since both grease and soap would choke the spaces between the card wires, which would lead to more neppy slivers and necessitate frequent cleaning of the card. Regarding mechanical alterations to the machine, fiber-breakage increases with increasing production, but there is less breakage at high than at low cylinder speeds. The adjustment of the rollers, one to the other, in the licker section of the machine does not produce any significant change in the mean fiber length of the sliver. While the setting of these rollers, within practical limits, does not apparently influence fiber-breakage, the carding action at the licker-divider points of contact is, on the other hand, responsible for quite a large reduction in the mean fiber length of the sliver. This is presumably caused by the reversal of the fibers at these carding points and by the fact that the licker must deposit material on the already crowded teeth of the dividers; it is believed that this fault would be reduced by rotating the latter rollers in the opposite direction. There is also a reduction in the degree of breakage when the card teeth are sharp and smooth, as was demonstrated by comparing slivers obtained before and after grinding. The greatest amount of fiber-breakage is undoubtedly due to the entangled state of the scoured wool when it is fed to the card. If fibers are fed to the machine in such a manner that they can be easily disentangled, as, for example, in the case of dry, pulled-up tops, then the amount of breakage in carding is relatively small. This does not imply that no breakage takes place in the opening section, for when the ratio of the surface speed of feed rollers and first lickerin was reduced by half, a slight increase in the fiber length was obtained. There is, however, no doubt that the normal entanglement of the wool fibers caused by scouring is the greatest contributory factor to the breakage which occurs in carding. A modified form of feed mechanism, which can be attached to any card, was devised to overcome this difficulty. This allows the wool to pass forward to the first licker in a more open and straighter state, while at the same time the great divergence in speed between feed rollers and licker is reduced. Comparison of slivers produced with the normal and modified feed mechanisms showed that the wool suffered far less fiber-breakage when the modified method was used. Authors

Text. Research J. Aug. 1946

Knitting Needles

Knitting needles vary infinitely in design. Max C. Miller. *Textile World* **96**, 102–15 (Apr. 1946).

A treatise on the various designs of needles for both flat and circular knitting machines. It is said that needle and machine design are inseparable, and many sketches of different types of needles and their action are given together with photographs of their applications. It is said that spring-beard needles are by far the best for producing all fine-gage fabrics, but that the latch needle, being more automatic in action, permits simpler machine design although it necessitates a sacrifice of fabric appearance and speed and a greater needle cost. Bolt needles are said to have many desirable characteristics and much improvement in them is predicted.

H. J. Burnham

Text. Research J. Aug. 1946

Carpet Manufacture

Carpet manufacture. W. J. Hopkins. *J. Text. Inst.* **37**, P61–71 (Apr. 1946).

A review of the basic principles of carpet manufacture. The determining factors of carpet quality are given as (*a*) pitch, (*b*) take-up, (*c*) height of pile, (*d*) quality of pile yarn, (*e*) stuffer, (*f*) quality of chain warp, and (*g*) quality of filling yarn. Detailed descriptions are given of the manufacture of the following types: Brussels Jacquard, Wilton Jacquard, Spool Axminster, and Jacquard or Gripper Axminster. The tufting mechanisms of the two types of Axminsters are illustrated by means of schematic diagrams.

Text. Research J. Aug. 1946 A. R. Martin

MISCELLANEOUS

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Chemistry of Cellulose Acetate

Chemistry of cellulose acetate. G. W. Seymour. *Colloid Chemistry* **6**, 887–916 (1946) (through *Chem. Abstr.* **40**, 2623[6] (May 10, 1946)).

Manufacture of cellulose acetate from wood and from cotton linters, pretreatment and acetylation of cellulose, ripening (deacetylation), precipitation, washing, formation of spinning solutions, spinning, and dyeing, and cellulose acetate plastics are discussed.

Text. Research J. Aug. 1946

Review of Color Science

Colour. G. S. J. White and T. Vickerstaff. *J. Soc. Dyers and Colourists* **61**, 213–23 (Sept. 1945).

The second John Mercer Lecture. A survey of modern knowledge of color, particularly as it relates to the art of dyeing and coloring textiles. Various aspects of the three variables, light source, object, and

observer, by which the color of an object is conditioned are discussed. Theories of vision, color-blindness, and color-measurement systems are described in some detail, and problems of especial present-day interest such as color harmony, a uniform chromaticity system, sensitivity of the eye in various spectral regions, adaptation of the eye (with regard to different light sources), theoretical limits of color, and prediction, from color measurement, of the amounts of dye required to match a given pattern are reviewed authoritatively. K. S. Campbell

Text. Research J. Aug. 1946

Cotton Bagging

Use of cotton bags for storing sugar. D. L. Sen and Nazir Ahmad. *Indian Text. J.* **56**, 135–41 (Nov. 1945).

This investigation was undertaken to determine whether it was practical to use cotton bags for storing sugar and thus assist in consuming the short-staple cottons of which there is generally a surplus in India. A special fabric was developed weighing 7 oz. per sq. yd. and having adequate strength and resistance to wear. Water-repellent treatments were investigated since moisture penetration through the bag might affect the sugar in storage. Two treatments were selected for service tests: (1) the cloth was padded with 6% aluminum acetate (3°Tw.), heated to 70°C for 1 hr., and then dried; and (2) same as (1), except that the cloth was further padded with 1% tannin solution before drying. Comparative storage tests were conducted in a closed wooden chamber in the laboratory and in a factory warehouse (godown), using ordinary jute bags and cotton bags which had been given treatments (1) and (2). The best results, as measured by fall in polysaccharose increase in invert sugar, and change in moisture content, were obtained with the cotton bags having treatment (1). Consideration of relative costs, however, shows that the use of cotton bags in preference to jute is not economical, even though the use of such bags offers certain advantages. R. K. Worner

Text. Research J. Aug. 1946

Ionization of Air

Electrical energy in air affects textiles. Peter M. Strang. *Am. Wool and Cotton Reptr.* **60**, 11–12, 49 (Apr. 18, 1946).

A report on the study of the effect of air ionization on the operation of cotton mills. It is said that New England and Ontario, which were in the zone of maximum intensity of the magnetic storm of 1940, experienced extreme static difficulties during processing while southern mills were running normally. Adverse running conditions in March and September are said to coincide with changes in radio reception. An attempt is made to indicate the similarity between current unexplained data in the textile industry and recent findings of scientists concerning sunspots and ionization of air. It is said that decreased ionization may afford southern mills an advantage in different machine speeds, less work per operative per lb. of product, and less variation in quality of product over New England mills making comparable products. H. J. Burnham

Text. Research J. Aug. 1946

Treatment of Jute

Jute and the chemical industry. W. G. Atkins. *Chemistry and Industry* **No. 6**, 58–61 (Feb 9, 1946).

A discussion of improved retting by chemical treatment, oiling, chemical bleaching, and dyeing of jute. The rotproofing of jute by various inorganic and organic treatments and the waterproofing of jute canvas are briefly mentioned. Jute fabrics may be useful in the preparation of plastic laminates. W. Raczynski

Text. Research J. Aug. 1946

Technology of Latex

Rubber latex technology. R. W. Albright and R. A. Lees. *Colloid Chemistry* **6**, 348–55 (1946) (through *Chem. Abstr.* **40**, 2668[7] (May 10, 1946)).

A discussion of the production and nature of latex and its treatment at the plantations; latex compounds; latex in industry; latex sponge; rubber thread; molded latex; latex insulation; metal-coating; fabrics-upholstery; can-sealing; road-surfacing; and floor compositions.

Text. Research J. Aug. 1946

Lignin

The utilization of lignin. F. E. Brauns. *TAPPI Bull.* **No. 84**, 3 pp. (Feb. 27, 1946) (through *Bull. Inst. Paper Chem.* **16**, 335 (Apr. 1946)).

Emphasizing the fact that the problem of lignin utilization in the United States is complicated through the availability of other cheap raw materials, the author reviews the different methods employed for utilizing lignin or lignin derivatives, regardless of whether or not they have any prospect of being used in this country. Lignin is obtained industrially either as a solid from wood-saccharification processes or in solution in the sulfite, soda, and sulfate processes. Of these materials, the sulfite waste liquor presents the main problem The various fields in which sulfite waste liquor as a whole or in the form of isolated lignosulfonic acid salts has been used are briefly discussed, including the manufacture of alcohol and yeast, as core binder, for briquets, as dust binder on roads, in soap, as tanning agents, as a cement-dispersing agent, as fertilizer, and in several minor applications. The ideal way to utilize sulfite waste liquor would be in the production of organic chemicals The only process of this kind so far is the manufacture of vanillin. In spite of the numerous fields in which sulfite waste liquor or lignosulfonates might be used, the amount actually employed is still very small, and the prospects of finding an economical use of the total sulfite waste liquor annually obtained are far from being bright. The two retarding factors are that the structure of lignin is still unknown and that cheaper and better raw materials are available. If legislation should forbid the dumping of the liquor into the streams, it might be simpler for the mills to change from the present calcium bisulfite liquor

to a sodium or magnesium base liquor and to recover the chemicals in the same way as in the alkaline processes.

Text. Research J. Aug. 1946

Madras Handkerchief Trade

The Madras handkerchief trade—its importance. V. G. Ramakrishna Ayyar. *Indian Text. J.* **56**, 109–11 (Nov. 1945).

Madras handkerchiefs are a class of colored, hand-woven fabrics, the production of which has furnished a livelihood to a large number of hand-loom weavers in the Madras Presidency. These fabrics are produced from grey and colored warp and filling yarns with the peculiarity "that certain warp yarns are caused to bleed during weaving and to tint the grey weft with the color of the warp, thus producing solid effects in those colors." Details are given for warp preparation and weaving. Attempts to produce these fabrics on power looms have resulted in inferior fabrics. The quantity and value of exports from 1914 to 1939 are tabulated. R. K. Worner

Text. Research J. Aug. 1946

Nylon Production

Nylon production technique is unique. James A. Lee. *Chem. and Met. Eng.* **53**, 96–9, 148–51 (Mar. 1946).

Details are given of the history of nylon manufacture, the preparation of the nylon "salt," evaporation, polymerization, casting, and spinning steps; and recovery of waste yarn. A short discussion is given of materials used in plant construction. Numerous photographs of the plant processes and a detailed flow sheet are included. R. W. Eyler

Text. Research J. Aug. 1946

Luminescent Pigments

Luminescent paints, pigments, and inks. Alexander Strobl. *Colloid Chemistry* **6**, 735–41 (1946) (through *Chem. Abstr.* **40**, 2651[2] (May 10, 1946)).

Fluorescence and phosphorescence are distinguished, and their causes considered; also "radium luminous pigments" and various phosphors, their manufacture and uses. The use of black light (ultraviolet) and a variety of scientific and practical applications are given.

Text. Research J. Aug. 1946

Rayon Production

Rayon in 1946. F. M. Whitney. *Chemurgic Digest* **5**, 25–6 (Jan. 15, 1946).

General discussion of the production of rayon, including high-tenacity rayon for tire cords, 1.0-denier viscose rayon staple, and shrink-resistant rayons. W. Raczynski

Text. Research J. Aug. 1946

Recording Instruments

Activity recording instruments applied to textile machinery. C. S. Parsons. *Cotton* **110**, 59–64 (Apr. 1946).

A description of the use of this type of instrument with particular reference to the study of loom stoppage in the weave room. A typical chart from a 20-pen activity recorder is shown and details of analyses of charts are given. It is said that substantial savings in the cost of time-study observations can be achieved. H. J. Burnham

Text. Research J. Aug. 1946

Chlorinated Rubber

Chlorinated rubber. John S. Tinsley. *Colloid Chemistry* **6**, 1118–26 (1946) (through *Chem. Abstr.* **40**, 2672[3] (May 10, 1946)).

History, commercial production, chemical theory, properties (solubility, stability, etc.), and uses are discussed. 37 references.

Text. Research J. Aug. 1946

Rubber and Plastics for Plant Construction

Rubber and plastics as materials of chemical plant construction. M. G. Fontana. *Chem. and Met. Eng.* **53**, 102–5, 109 (Apr. 1946).

A concise review of uses of 5 types of synthetic rubber and 8 different plastics in plant construction. Several examples of their use in rayon plants are discussed. GR-S, butyl, GR-A, Thiokol, and neoprene synthetic rubbers; and phenolic, vinyl, nylon, polythene, Haveg, styrene, acrylic, and silicone plastics are included. Several useful tables and charts summarize the effects of various chemical materials on these rubbers and plastics and describe their physical properties. 13 references. R. W. Eyler

Text. Research J. Aug. 1946

Moisture Relations of Tire Cords

Moisture relations of tire cords in tires. Helmut R. R. Wakeham, Edith Honold, and H. J. Portas. *India Rubber World* **113**, 659–62, 721 (1946) (through *Chem. Abstr.* **40**, 2678[5] (May 10, 1946)).

Opinions regarding the moisture contents of cords in tires have been so divergent that an experimental study of the subject was undertaken with actual tires. The experimental technique, which involved the removal of cords from tires and weighing without significant moisture-exchange with the air, is described in detail. The data which were collected concern chiefly the effects of storage, of exposure to different temperatures and humidities, and of wheel-test operation on the moisture content of cords. The results indicate that the environmental condition is the factor which has the most determinant effect on the moisture content of cords in a tire. When the surrounding atmosphere is practically invariable, as in storage, the moisture content of tire cord probably reaches equilibrium with the average atmospheric conditions. In a humid climate, the moisture content should be relatively high. Even when a tire is operated under conditions conducive to high temperatures in the tire, considerable time is required for the cord to lose appreciable moisture through the rubber. These conditions lead to important consequences. If a tire is built under conditions when the fabric is dry, e.g., 2–3% moisture, there is no

certainty that the moisture will remain at these low levels. There are probably climatic and operating conditions under which cords remain relatively dry, but they are infrequent. The moisture and temperature levels at which cords are tested to predict the performance of tire fabrics should be so chosen as to take into account the moisture contents of the cords in the tire. Dillon and Prettyman (*C.A.* **39**, 2667[2]) have shown that temperature and humidity have profound influences on the physical properties of tire cords. Their work and the results of the present investigation emphasize the importance of measuring the physical properties of tire cords through a wide range of moisture contents.

Text. Research J. Aug. 1946

Starch Films

Film properties and utilization of resin-starch. C. C. Kesler, J. E. Killinger, and E. T. Hjermstad. *Paper Trade J.* **122**, TAPPI 133–7 (March 28, 1946) (through *Bull. Inst. Paper Chem.* **16**, 367 (Apr. 1946)).

Studies of moisture sorption and shrinkage on drying of films of starch and other materials showed that though the amount of shrinkage is limited to some extent by the moisture retained, wide variations in shrinkage were observed by materials whose films may retain approximately the same percentage of moisture. High shrinkage values were obtained with starches from which amylose may be obtained, and low values from starches which yield little or no amylose upon fractionation. Treatment of corn starches with urea-formaldehyde resin reduced shrinkage of their films, depending on the amount of resin used. The use of the starch-resin reaction product resulted in a number of advantages. Coating, tub, and calender sizing operations verify the validity of film studies as a measure of the suitability of materials for the production of desirable end uses. Clay coatings gave good wax tests and printability, high gloss, and, if desired, increased coating weights. Actual tub-sizing operations showed increased bursting strength and fold-resistance, greatly increased porosity and oil-absorption values, higher gloss and smoothness, and improved erasure and pen-and-ink values. Calender applications—where less pickup results—gave improved surface characteristics with pronounced improvement in scuff test, both wet and dry.

Text. Research J. Aug. 1946

Production of Sodium Alginate

Production and uses of sodium alginate. Maria Alegre D. and Alejandro Aldea L. *Anales quím. farm.* **1945** in *Rev. quím. farm.* **35**, 7–11 (1945) (through *Chem. Abstr.* **40**, 2930[7] (May 20, 1946)).

To 1 kg. of dried seaweed (*Durvillea utilis, Fucaceae*) is added sufficient 2.5% Na_2CO_3 solution to form a thick paste which is macerated 24–48 hrs. The Na alginate solution thus formed is lower in viscosity and can be decanted. Purification is by precipitation with HCl. Some color can be removed by treating the alkaline solution with NaOCl followed by HCl. Repetition of this process gives a very pale yellow product equal to the imported material. The yield varies from 27.2 to 32.5% (31.5–36.8% for the first precipitate). The use of the product as an emulsant in pharmaceutical preparations in pills, in water colors, printing of cloth, and production of textile fibers is discussed. Use of the home product is encouraged.

Text. Research J. Aug. 1946

Nonwoven Textiles

Nonwoven textiles—their packaging applications. Anon. *Modern Packaging* **19**, 100–5, 168, 170 (Feb. 1946); cf. *B.I.P.C.* **16**, 133–4 (through *Bull. Inst. Paper Chem.* **16**, 329 (Apr. 1946)).

Bonded webs of textile fibers—which handle like paper but have the properties of cloth—offer some interesting possibilities in packaging. During the war, the nonwoven textiles had very limited production and the available supply was taken for a few essential uses; their peacetime applications have scarcely been explored. Reference is made to the three types now in production, Webril, Bonnlinn, and Masslinn. The entire output of Webril (the heat-sealing type) was used for the manufacture of silica-gel bags; both Webril and Bonnlinn find application for tea bags. The flannel-like Masslinn has made an important packaging contribution as the wax-absorbing inner component of the Aquatex closure for multiwall paper bags. An illustrated description of the manufacture of tea bags, silica-gel bags, and multiwall-bag closures, and of the machinery employed is given. Future possibilities for this type of material are mentioned.

Text. Research J. Aug. 1946

Apparel Sizes in Europe

U. S. and European apparel-sizing systems. Virginia R. Collier. *Foreign Commerce Weekly* **22**, 12–13 (Mar. 30, 1946).

European clothing sizes are based mostly on a conversion from centimeters instead of from inches. Tables are given showing the comparison between American and European apparel sizes. Peculiarities of size systems in various countries are noted. R. B. Evans

Text. Research J. Aug. 1946

Stain Removers

Stain removers. Milton A. Lesser. *Soap San. Chem.* **22**, 33–5, 145, 147 (1946) (through *Chem. Abstr.* **40**, 2657[9] (May 10, 1946)).

This review contains 14 typical formulas. 19 references.

Text. Research J. Aug. 1946

Synthetic Detergents

What's ahead for synthetic detergents? Anon. *Chemical Industries* **58**, 964–6, 973 (June 1946).

A review of the potential market.

Text. Research J. Aug. 1946 A. R. Martin

Labor-Union Agreements

Union agreements in the cotton-textile industry. Rose Theodore.

Monthly Labor Review **62**, 413–23 (Mar. 1946).

About a third of the 407,000 wage earners in the cotton-textile industry in 1945 were covered by union agreements, including 60% of the employees in northern mills and less than 20% in southern mills. The Textile Workers Union of America (C.I.O.) represented slightly over 80% of the workers under agreement; the United Textile Workers of America (A. F. of L.), almost one-fifth. Of approximately 140 agreements in the industry, 45 are analyzed in the study in regard to provisions for union status, wages, piece rates, hours and overtime, vacations, seniority, adjustments of disputes, arbitration, and strikes. Only 7 of the agreements analyzed provided for an automatic checkoff of union dues but 32 provide for deduction of union dues upon specific authority of the employee. All agreements contain seniority provisions but nearly all state that seniority shall not be considered in promotion to supervisory jobs. All contracts restrict work stoppages and establish grievance machinery, and all but one provide for impartial arbitration of disputes.

Text. Research J. Aug. 1946 R. B. Evans

Wool Production and Marketing

Investigations of the production, transportation, and marketing of wool. Hearings before the Special Committee to Investigate the Production, Transportation, and Marketing of Wool, United States Senate, Part 6, Nov. 19–27, and Dec. 6, 1945, 909–1526. Washington, U. S. Government Printing Office, 1946.

This publication contains voluminous testimony and exhibits given to a Senate committee regarding the domestic wool situation. Because of rising costs and an uncertain outlook, the number of breeding sheep in the United States has declined 25% since 1942. Although wool production in this country is insufficient for domestic requirements, the British dominions have accumulated huge stocks during the war which it is estimated will require 13 yrs. to eliminate. According to cost studies made by the Tariff Commission and the Farm Credit Administration, the cost of producing wool in the Western States increased from 24.6¢ per lb. in 1940 to 46.9¢ per lb. in 1944, while profits rose from 5.4¢ per lb. in 1940 to 11.5¢ per lb. in 1942, then declined to a loss of 3.1¢ per lb. in 1944. Wool accounted for 48.7% of the income from sheep production in 1944 in these states. Labor costs, accounting for 42% of the cost of raising sheep during 1940–44, rose 89% from 1940 to 1944. A core-sampling method for predicting scoured-wool yields has been developed recently by the U. S. Department of Agriculture. Wool bags are cut and samples removed by use of a device consisting of an electric drill and a tube 3 in. in diameter equipped with a removable cutting edge. The samples are weighed, cleaned, and analyzed for moisture, grease, ash, and vegetable matter in the laboratory, after which the clean weight is corrected to a standard content of impurities. In a series of controlled experiments, core samples agreed with mill yields within + 1.6 and − 1.4% as compared with appraisal estimates ranging from + 8.4 to − 8.9%. R. B. Evans

Text. Research J. Aug. 1946

Industrial Libraries

Operating an abstracting and information service within an industrial organization. W. C. E. Barnes. *J. Chem. Education* **23**, 152–3 (Mar. 1946) (through *Bull. Inst. Paper Chem.* **16**, 392 (May 1946)).

The procedures employed by a British industrial organization are outlined, describing the methods used for the selection of articles of interest and bringing them quickly to the attention of those whom they most concern. The heads of the departments indicate by different signs the importance of the articles and the manner in which they should be recorded—by reference card only, by copied abstract, or by specially prepared abstract—and whether literature should be ordered or photostat copy made. This information is noted on the reference cards and the signs in the journals covered with colored seals, each seal denoting a fact—e.g., yellow, that an abstract has been made; blue, reference card only, etc. Not until journals have been fully recorded are they released for circulation; it is claimed that the delay is not greater than four days. The abstracts are collected in a bulletin and circulated with a form for ordering. A number is assigned to each abstract and all reference to it is made by number only. Cards of different colors are again used which bring groups of allied subjects together. A record book is kept for incoming and outgoing literature borrowed from the large technical libraries; a sample page is shown. Colored seals are employed to indicate the status of a publication—whether the literature itself is on hand, out on loan, unobtainable, etc. Borrowed periodicals are not circulated, but photostated immediately and returned to the appropriate library. The methods of filing photostats in numbered envelopes and the books used for keeping a check on the different items—whether sent out on loan to an individual or the photostating service, name of individual requesting the copy, etc.—are described. The method has been in operation in the organization for 18 months and has proved very workable.

Text. Research J. Aug. 1946

WAR RESEARCH ON TEXTILES*

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U. S. Research

Kapok Substitutes

Buoyancy studies of fiber substitutes for kapok. (OPRD Contract WPB-133.) F. M. Tiller. O.P.B. Report PB 16390, Sept. 1944; 73 pp.; limited free distribution; thereafter, microfilm, $1.00

* Copies of the original reports abstracted in this section may be obtained from the U. S. Department of Commerce, Office of Technical Services, Washington 25, D.C.

—photostat, $5.00 (through *Bib. Sci. and Ind. Reports* **1**, 1280 (May 31, 1946)).

Part I gives information on the evaluation of optimum densities for kapok, cotton, *Typha*, and fiberglass, correlation of buoyancy-vs.-time data including the effect of cage depth, and multicompartment pads. Part II covers original objectives of the studies, recommendations, rewriting of specifications, and testing procedure for new materials. Tables and 36 graphs are given. The laboratory work was conducted by Vanderbilt University.

Text. Research J. Aug. 1946

Mildewproofing

Report on mildewproofing and rotproofing cotton fabrics with a combination of copper naphthenate and compound G-4T. (NDRC Misc. Rept. 13, Tropical Deterioration Administrative Committee Rept. TDIC-33.) Givaudan-Delawanna, Inc. O.P.B. Report PB 18466, Feb. 1945; 5 pp.; microfilm, 50¢—photostat, $1.00 (through *Bib. Sci. and Ind. Reports* **1**, 1279 (May 31, 1946)).

This report contains the formulas used for treating OD webbing with copper naphthenate and a nondurable type of water-repellent. All samples were tested by the soil-burial test. Test data are recorded in tabular form.

Text. Research J. Aug. 1946

Fabric Resistance to Insects

Resistance of cellulose acetate, nylon and other fabrics to attack by insects, Jan. 27–Mar. 6, 1943. (NDRC Misc. Rept. 1, Tropical Deterioration Administrative Committee Rept. TDIC-6.) A. H. Goddin. O.P.B. Report PB 18462, July 1944; 12 pp.; microfilm, 50¢—photostat, $1.00 (through *Bib. Sci. and Ind. Reports* **1**, 1279 (May 31, 1946)).

This report describes the various tests which were conducted to discover: (1) if insects would attack fabrics based on cellulose; (2) if nylon film will protect certain food from attack by insects. Tests included subsistence tests conducted with four species of fabric tests, barrier tests, and defiling tests. Results proved that in general the various species of insect attacked and considerably damaged almost all of the fabrics but that none of them were able to damage nylon other than by "toothmarks." Carpet beetles and clothes moths caused moderate damage to nylon but in general the damage to nylon fabrics was less than that to cellulose fabrics.

Text. Research J. Aug. 1946

German Research

Calorimeter

Messungen von Verdünnungswärmen und Benetzungswärmen mit dem Unterwassermetallblockkalorimeter. (Measurement of the heat of dilution and the heat of wetting with an underwater metal block calorimeter.) (ALSOS Mission, RFR 302.) Karl Lauer and O. Wilde. O.P.B. Report PB 18434, Sept. 1944; 5 pp.; microfilm, 50¢—photostat, $1.00 (through *Bib. Sci. and Ind. Reports* **1**, 1277 (May 31, 1946)).

This calorimeter was considered most suitable for the purpose. The heat liberated by the action of toluene on cotton and cellulose wool and of acetic acid on cotton and cellulose wool was measured. The preparation of the sample and the instrument used are described.

Text. Research J. Aug. 1946

Elasticity of Wool

Über das Dehnungsverhalten von Wolle und synthetischen Wolltypen. (On the elasticity of wool and synthetic wool types.) (ALSOS Mission, RFR 303.) Karl Lauer and others. O.P.B. Report PB 18433, July 1944; 14 pp.; microfilm, 50¢—photostat, $1.00 (through *Bib. Sci. and Ind. Reports* **1**, 1276 (May 31, 1946)).

Tests were conducted upon wool, viscose, and other synthetic fibers to test their elasticity and breaking point. Some discussion of the relationship between the elasticity and the breaking point is included. 10 graphs are presented.

Text. Research J. Aug. 1946

Narrow Fabrics

Investigation of the German narrow fabric industry. (FIAT Final Rept. 462.) B. A. Holgate. O.P.B. Report PB 17549, 1945; 10 pp.; microfilm, 50¢—photostat, $1.00 (through *Bib. Sci. and Ind. Reports* **1**, 1277 (May 31, 1946)).

The narrow fabric industry of Germany consisted of about 1,100 to 1,200 plants, 50% of which were located in the Ruhr section. The plants inspected are listed in the appendix and are representative of the industry. The greatest asset of the industry was the availability of adequate cheap labor. The Guido-Horn braider was of importance because of its high rate of production and of its relatively low maintenance cost.

Text. Research J. Aug. 1946

Indanthrene Dyes

Eigenschaften und Anwendung der Indanthrenfarbstoffe. (Properties and application of indanthrene dyes.) I. G. Farbenindustrie, Frankfort on the Main. O.P.B. Report PB 19933, n.d.; 392 pp.; microfilm, $6.00—photostat, $37.00 (through *Bib. Sci. and Ind. Reports* **1**, 1217 (May 31, 1946)).

This book, designated by the firm as "strictly confidential" and issued "for personal use of our representatives only," contains full instructions for users of I. G. Farbenindustrie indanthrene dyes. All important points are discussed which must be considered for perfect results with any of the dyes with special attention to difficult and complicated jobs. Several types of fibers (cotton, mercerized cotton, rayon, cellulose fibers, silk, etc.) are used as examples in the application of specific dyes and dyeing methods, and special instructions are given for material of mixed fibers. "Tone-on-tone" dyeing receives specific attention, particularly in application to mixed-fiber textiles. Starting with a general introduction, the book is divided into 4 parts, 3

of which contain textual material and the 4th is a collection of tables. Part 1 deals with formulas for setting up the dye bath for a certain color ratio and the conversion of these formulas to other ratios, both for the original bath and for supplementation when partly used up. Examples for various types of dyes are given. Part 2 deals exclusively with methods for uniform dyeing of materials made of fibers of the same kind, source, crop, fineness, etc., on materials of the same kind but perhaps different crop or source, and on materials of mixed kind, type, and physical properties. Part 3 deals with properties and special coloring behavior of indanthrene dyes, the precautions which have to be taken in using them successfully, and technical problems coming up in the dye house. Part 4 contains most of the dye information dealt with in the other 3 parts in tabulated form. Some of the graphs and other material are in color, which, of course, will show up only as black and white on reproduction. In German.

Text. Research J. Aug. 1946

German Uniform Fabric

The German Army standard uniform cloth, "Einheitstuch." Werner von Bergen. (QM Textile Series, Rept. 8.) O.P.B. Report PB 22341, Mar. 1946; 30 pp.; microfilm, 50¢—photostat, $2.00 (through *Bib. Sci. and Ind. Reports* 1, 1276 (May 31, 1946)).

The study of captured German uniforms during the war, both of the German Army and the SS, revealed that the use of wool in the basic fabric was being progressively and drastically reduced. It was also apparent that the German conception of the camouflage color for the wool uniform was undergoing a change along with the modification of the camouflage coloring of cotton-type fabrics. The report covering these developments is in 3 sections, namely, the dyeing of the uniform fabric, the composition of the fabric, and specifications requirements on delivery acceptance, issued by German Army Supply Section, May, 1940. Much of the data included is given in tabular form. Diagram of the construction of a dye house is given.

Text. Research J. Aug. 1946

Swelling of Fibers

Quellfestmachung Fasern (Parts 2, 3, 4). (Swell-resistant fibers.) (ALSOS Mission, RFR 303.) Karl Lauer and others. O.P.B. Report PB 18432, July 1944; 14 pp.; microfilm, 50¢—photostat, $1.00 (through *Bib. Sci. and Ind. Reports* 1, 1277 (May 31, 1946)).

Several catalysts and their action on the physical properties of synthetic fibers were compared. The swelling of fibers, their elasticity, effects of temperature, drying for varying periods, pH of buffer solutions were all noted. Graphs, tables.

Text. Research J. Aug. 1946

Textile Finishing

German technical developments in textile finishing processes. (QM Textile Series, Rept. 3.) Francis S. Richardson. O.P.B. Report PB 22337, Mar. 1946; 222 pp.; microfilm, $2.50—photostat, $15.00 (through *Bib. Sci. and Ind. Reports* 1, 1277 (May 31, 1946)).

This report is divided into the following sections: I. German textile processing and equipment; II. mandatory Order No. 7 by the Special Commission for the German Textile Industry, and directions for the bleaching of textile raw materials, yarns, and fabrics, effective Dec. 15, 1940; III. instructions No. 60/42 by the Manager of the Wirtschaftsgruppe Textilindustrie, and directions for the bleaching of textile raw materials, yarns, and fabrics; IV. bleaching procedures for cotton, rayon, staple, and blends, a series of papers by H. Korte and his associates in the Textile Application Laboratory, I. G. Farben; V. camouflage fabrics both plain and printed for military use by the German SS and German Army; VI. the German shelter half; VII. engraving for printing; VIII. softening agents for the finishing of cotton and spun rayon fabrics—"Soromin" brands, research report of Textile Application Laboratory, I. G. Farben, Höchst; IX. chemistry and techniques of swellingproof finishes, lecture of Dr. Gutman before Chemists of Dyestuff Manufacturers, March, 1945; X. preserving agents for technical purposes, especially for the glue, paper, and textile industries, research report of Textile Application Laboratory, I. G. Farben, Höchst; XI. textile auxiliaries in aqueous dispersions, also an I. G. Farben research report. A drawing is included for Reichspatent No. 728729, Class 8a, Group 9 70, H 164050 VII/8a, issued December 2, 1942, to Heinrich Habig, A. G., at Herdecke, Ruhr. It is apparent that the machine covered by this patent was particularly effective in developing "Indigosol" dyed fabrics by the nitrite process. Digests of the following patents are also included: Reichspatent No. 993345, Class 8c, Group 11 ol, H 152743 VII/8c issued to Gustav Mark in Herdecke, Ruhr, concerning a type of mandrel bearing for textile print machine rollers, and accompanied by 3 drawings; and German Patent No. 7774 issued to Franz Nesletberger, concerning heat treatment of textile material. Texts of the following articles (in the original German) are given: 1. "Bemerkungen zu den Neuerungen in der Baumwollbleiche," by H. Korte, reprint from *Monatschrift für Textilindustrie*, 1931, numbers 10 and 11. This is a discussion of four different bleaching methods—boiling chlorine, Griesheimer intermediate hot-water treatment, oxygen, and combination bleaching (hypochlorite-oxygen)—on the warp beam. 2. "Das Bleichen und Veredeln von Mischgespinsten und—Geweben," by H. Korte and others, reprint from *Melliand Textilberichte*, 1936, numbers 10 and 11. This is a discussion of whether the usual bleaching methods mentioned above can be applied to textiles of low blend ratios, i.e., 84% cotton and 16% staple rayon. Text in German is also given of the following: Reichspatent No. 615680, Class 8i Group 2, I 41822 IVc/8i issued July 9, 1935, to I. G. Farbenindustrie, A. G., Frankfort on the Main, concerning combination bleaching method, alkaline hypochlorite pre-

bleaching and subsequent treatment with peroxide; "Abkochen, Beuchen und Bleichen," an I. G. Farben illustrated publication proclaiming the merits of their new bleaching agents—Nuva B, Igepal F, etc. Tables, graphs, and drawings are included.

Text. Research J. Aug. 1946

Preparation of Flax and Hemp

Preparation of flax and hemp fibers in Germany. (FIAT Final Rept. 548.) B. B. Robinson. O.P.B. Report PB 17554, Dec. 1945; 19 pp.; microfilm, 50¢—photostat, $2.00 (through *Bib. Sci. and Ind. Reports* 1, 1278 (May 31, 1946)).

The methods and machines used in the German raw flax, and hemp fiber, industries are in general similar to those used in other countries where the preparation and cleansing of these fibers have been industrialized and are no longer peasant industries. The reduction by mechanical means of the water content of wet flax straw after removal from a retting tank has received the attention of inventors and processors for many years. The use of pressure rollers is not new but their employment on a large scale as practiced in Germany is none too common. The proper understanding of their effect on the quality of this fiber is so conflicting that their use is worthy of note for American processors where the employment of some similar method might be of value for winter retting. Differences between flax and hemp, and flockenbast and cotton, are discussed. Machines for the preparation of flax and hemp fibers, as well as chemical processes used in the preparation of flockenbast, are described. The method of determining the class and price of straw based on a point system is shown in tabular form. A list of factories and research organizations used as sources of information are included. Photographs of raw materials, photograph of Lindner flax harvester, and diagram-indicating machines and steps used in the preliminary cleaning, chemical cooking, mechanical after-opening and spinning of mixed flockenbast and staple rayon are shown.

Text. Research J. Aug. 1946

Protective Clothing

Developments in protective clothing in Germany. (BIOS Final Rept. 152, Items 22, 27.) A. C. Burton. O.P.B. Report PB 18931, June–July 1945; 26 pp.; microfilm, 50¢—photostat, $2.00 (through *Bib. Sci. and Ind. Reports* 1, 1276 (May 31, 1946)).

Although the subject of protective clothing was greatly neglected in Germany during the war, a foam protective suit and a suit for fire protection were developed. These suits, as well as flameproofing and fireproof fabrics, protective clothing against cold, water-repellency and water vapor in clothing, and field testing in Germany, are described. The foam protective suit was developed for the protection of airmen and others suffering immersion in cold water. The suit is impregnated with a powder which, it is claimed, upon contact with the water releases a stable foam which excludes further water and provides buoyance and warmth.

Text. Research J. Aug. 1946

Lehrspinnerei

Lehrspinnerei (model spinning mill), Denkendorf. (BIOS Final Rept. 88, Items 22, 31.) P. Larose and A. C. Burton. O.P.B. Report PB 18912, Aug. 1945; 31 pp.; microfilm, 50¢—photostat, $3.00 (through *Bib. Sci. and Ind. Reports* 1, 1277 (May 31, 1946)).

The purpose of this model spinning plant, founded in 1936 for the benefit of the industry and financially supported by it, was to try out new ideas on a plant scale. During the war most of the work was carried on with rayon. Many improvements in machinery have been made including those concerned with drafting. An outstanding development is the use of machine belting of vinyl plastic instead of leather. The feature of the drafting (3-rollers) was a self-aligning pendulum suspension. An explanation of the action of the pendulum suspension with sketches is presented in Appendix 1. Theoretical research resulted in obtaining a formula for the preparation of fibers giving the maximum elongation for different values of the draft-ratio and the ratio of the fiber length to the distance between the rollers. A summary translation of the best proof of this formula (Denkendorf Report IIa, pp. 37–49, 1944, "The elongation of the fiber in relation to the draft ratio and the distance between the rollers"), accompanied by a table for various drafting ratios and distances between rollers, is given in Appendix 2. Experimental research has also been done on the optimum draft-ratio. An apparatus was used that recorded, on an ink-writing milliammeter recorder, the tension on the fibers between the rollers. This apparatus was applied to the actual spinning frame. Records have been obtained of the tension and the frequency of breakage of ends, with different draft-ratios. The translation of a sample report published by the Lehrspinnerei ("Phenomena during drafting with the ring spinning frame," Denkendorf Report I. E., p. 12) is given in Appendix 3. The photographs and graphs accompanying this article will not reproduce well.

Text. Research J. Aug. 1946

Textile Laboratory

Textilforschungsanstalt, Alderstrasse, Krefeld. (BIOS Final Rept. 155, Item 22.) P. Larose and A. C. Burton. O.P.B. Report PB 18932, Sept. 1945; 6 pp.; microfilm, 50¢—photostat, $1.00 (through *Bib. Sci. and Ind. Reports* 1, 1277 (May 31, 1946)).

The laboratory is engaged principally in research and testing of rayon fibers. It is supported by the industry, chiefly spinners and weavers, and not by the state. The following work of the Institute is discussed: effect of processing on properties of fibers, abrasion tests, viscosity measurements, yarn-uniformity tests, and miscellaneous tests. Chief interest has been on changes in properties of fibers as a

result of various chemical treatments and also during use.
Text. Research J. Aug. 1946

Textile Testing

Textile testing in Germany. (BIOS Final Rept. 178, Item 22.) A. C. Burton and P. Larose. O.P.B. Report PB 18942, Aug.–Oct. 1945; 45 pp.; microfilm, 50¢—photostat, $3.00 (through *Bib. Sci. and Ind. Reports* 1, 1276 (May 31, 1946)).

Brief descriptions of visits to the following targets are given: I. G. Farbenindustrie, Höchst; Lehrspinnerei, Denkendorf (near Esslingen); Deutscher Forschungsinstitut für Textilindustrie, Reutlingen; Vereinigte Glanzstoff, Wuppertal-Elberfeld; Textilforschungsanstalt, Krefeld; Textile Ausrustung Gesellschaft Schroers & Co., Krefeld; *Melliand Textilberichte*, Heidelberg; Forschungsinstitut für Textilindustrie und Höheren Fachschule für Textilindustrie, Hohenstein Schloss, near Bonningheim; Textillaboratorium "De Voorzorg," Enschede, Holland; Comptoir des Textiles Artificiels, Paris, France. Although some of the textile-testing methods used in Germany are different from those used in America and although some new developments had taken place during the war, it was concluded that the state of their testing procedure as a whole was not in advance of that used in the United States or Canada, and in some respects it may be considered as not quite of the same standard. Testing methods are discussed and sketches and photographs of machines used are shown under the following headings: abrasion machines (wear testers), yarn uniformity, breaking-strength testers, thermal insulation, air permeability, viscosimetry and rayon-quality control, analysis of dissolved cellulose, water-repellency, shrinkage, soil-removal, dye fastness, and miscellaneous tests and equipment.
Text. Research J. Aug. 1946

Rayon Weaving

Rayon weaving and throwing in Germany. (FIAT Final Rept. 554.) Ernest C. Geier. O.P.B. Report PB 18788, Dec. 1945; 29 pp.; microfilm, 50¢—photostat, $2.00 (through *Bib. Sci. and Ind. Reports* 1, 1276 (May 31, 1946)).

This report on the rayon weaving and throwing industry in Germany concerns itself chiefly with the usage and application of filament yarns and does not embrace the staple- or spun-rayon field. Descriptions are given of the following novel developments or methods which merit attention: 1. the double-twist spindle (Doppel Draht) specifically designed for high twist crepe throwing (Barmag); 2. the hollow-spindle used as a combination up-twister-doubler (Kuag); 3. the three-deck uptwister for rayon or silk crepe yarns (Hamel & Company); 4. the loom without a superstructure built by Ruti, Elmag, Saurer; 5. the plastic heddle to replace the steel heddle (Fentin & Guilleaume); 6. the Kreuzwalken apparatus to increase density (picks) in fabrics (Sächsische Webstuhlfabrik); 7. the printing of aviators' maps, particularly for night flying, printed in a textile print shop (Verseidag); 8. the continuous process of cupra yarn from spinneret to warp beam or spools (J. P. Bemberg). The appendices contain drawings and diagrams of some of these novel developments and methods, a price list for German rayon yarn for November, 1945, a description of Patent No. 740024, "Method of producing durable, especially multicolored maps," and a description of "Wollin" fabrics as adopted for civilian purposes. A list of the plants visited is included.
Text. Research J. Aug. 1946

Italian Hemp Industry

The Italian hemp industry. (FIAT Final Rept. 547.) Brittain B. Robinson and Charles W. Schoffstall. O.P.B. Report PB 17555, 1945; 15 pp.; microfilm, 50¢—photostat, $1.00 (through *Bib. Sci. and Ind. Reports* 1, 1278 (May 31, 1946)).

The hemp industry of Italy is largely under the control of a national organization, Consorzio Nazionale Canopa, the main office of which is in Milan, with branch offices in Bologna, Rome, Naples, etc. This organization appears to be closely associated with the Linificio e Canapificio Associazione, the head office of which is also in Milan. The organizations fix the prices for the various grades of fiber and appear to control through purchases and manufacturing operations about 85% of the raw fiber hemp industry of Italy. The fiber of the raw fiber hemp grown in Italy is principally prepared on small farms as a peasant industry. The production in Italy has not become industrialized to any great extent as it has in many countries where the retting and cleaning of the fiber is carried on as a factory process. As a result the methods followed and the machinery used are very primitive and require a great amount of hand labor. There are no steps in the production that can be considered worthy of recommendation for adoption in the United States. Tables present raw hemp prices for the northern areas and for the Naples area of Italy. Principal persons interviewed are listed.
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PATENT REFERENCES

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Cotton Chopper

Cotton chopper. William H. Clark. U. S. 2,399,854 (May 7, 1946).

A machine for chopping (or thinning out) cotton plants.
Text. Research J. Aug. 1946

Cotton Harvester

Cotton harvester. David B. Baker and Clarence R. Hagen (to International Harvester Co.). U. S. 2,399,718 (May 7, 1946).

A tractor-mounted harvester in which the cotton is conveyed from the picking mechanism to the receptacle by means of a fan but without passing the cotton through the blades of the fan.
Text. Research J. Aug. 1946

Elastic Fabrics

Fabric and method of making the same. Abraham A. Kahil. U. S.

2,401,828, 2,401,829, and 2,401,-830 (June 11, 1946).

Process consists of weaving certain threads under tension, which, when released, causes the threads to curl or kink.

Text. Research J. Aug. 1946

Noncurling Fabrics

Unidirectional-twist woven fabric and method. Ross C. Whitman (to The Kendall Co.). U. S. 2,400,182 (May 14, 1946). **Opposite-twist woven fabric and method.** Ross C. Whitman (to The Kendall Co.). U. S. 2,400,276 (May 14, 1946).

An invention directed principally to stiffened fabrics, both wide and narrow. By means of proper selection of yarn size and of the amount and direction of twist in the warp and filling yarns, the tendency of treated fabrics to curl may be overcome. The factors influencing fabric curl are discussed.

Text. Research J. Aug. 1946

Resin-impregnated woven textile fabric and method of producing the same. Ross C. Whitman (to The Kendall Co.). U. S. 2,400,379 (May 14, 1946).

A method of producing a woven fabric for industrial uses having moisture-resistant stiffness characteristics and substantially no tendency to curl.

Text. Research J. Aug. 1946

Treatment of Keratin Fibers

Composition for treating keratin fibers. John Bamber Speakman (to Perm, Ltd.). U. S. 2,400,377 (May 14, 1946).

A process for treating wool or hair which releases the stress by causing the disruption of the disulfide bonds of keratin and which is effective when operated at temperatures below the boiling point and as low as room temperature if desired. The invention is applicable to the removal of distortion in knitted fabrics arising from uneven stress in the yarn. Yarns for the manufacture of curl fabrics or artificial astrakan and Persian lamb fabrics may be given a permanent set. The treatment is also useful in the permanent waving of hair.

Text. Research J. Aug. 1946

A Twisting Spindle

Twisting spindle for spinning, twisting, and like machines. Geoffrey Curtis (to Courtaulds Ltd.). U. S. 2,402,028 (June 11, 1946).

An improved apparatus in which the spindle is designed for at least 7,000 revolutions per minute and is arranged to have a low natural frequency of vibration when loaded with the yarn.

Text. Research J. Aug. 1946

Thread Impregnation

Method of wetting thread. Alfred Burgeni and Roy L. Keown (to The Clark Thread Co.). U. S. 2,398,516 (Apr. 16, 1946).

A device for treating a fibrous strand with a liquid finishing agent stated to make possible a thoroughness and control of treatment not hitherto obtainable.

Text. Research J. Aug. 1946

Long-Draft Spinning Apron

Long-draft spinning apron. Henry M. Bacon and Abraham L. Freedlander (to The Dayton Rubber Mfg. Co.). U. S. 2,402,356 (June 18, 1946).

An improved long-draft apron made of a combined synthetic rubber and fiber composition or of synthetic resin-and-fiber composition having the proper coefficient of friction at its surface to carry the fibers through the drafting unit in a uniformly straight line so that slippage is not encountered.

Text. Research J. Aug. 1946

Surface Tension

Measurement of surface tension. Homer L. Cupples (to the United States of America, as represented by the Secretary of Agriculture). U. S. 2,401,053 (May 28, 1946).

An improved apparatus and procedure for determining surface tension of liquids which employs the well-known maximum-bubble-pressure method.

Text. Research J. Aug. 1946

Water-Repellent Finishes

Treatment of textiles. David Aelony (to Monsanto Chemical Co.). U. S. 2,398,272 (Apr. 9, 1946).

Water-repellent and mold-resistant finishes employing *N*-alkyl carbamyl or *N*-alkyl sulfamyl substitution products of benzoic acid.

Text. Research J. Aug. 1946

Winding Mechanism

Textile machine. William J. Elvin (to Celanese Corporation of America). U. S. 2,401,725 (June 11, 1946).

An improved take-up means for winders and twisters for the production of packages of yarn which are perfectly wound as to the density and traverse and which will be substantially free from broken filaments.

Text. Research J. Aug. 1946

Nonfelting Wool

Treatment of wool. Archibald John Hall and Frederick Charles Wood (to Tootal Broadhurst Lee Co., Ltd.). U. S. 2,401,479 (June 4, 1946).

A reduction in the tendency of wool to felt or shrink is obtained by treatment with caustic soda dispersed in monohydric alcohol. Adequate control of results, quality, and decrease of felting power of the treated wool can be had by varying certain factors which are listed.

Text. Research J. Aug. 1946

Wool Scouring

Wool scouring process and compositions. Samuel T. Woodside (to Lucson Corporation). U. S. 2,395,085 (Feb. 19, 1946).

In the process described, kerosene and pine oil in approximately equal proportions are added to the usual soap-alkali scouring bath. It is stated that the kerosene and pine oil cancel out the odor of each other and that the addition of these oils enhances the cleansing action of the bath and also permits a reduction in the alkalinity of the bath.

Text. Research J. Aug. 1946